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MELBOURNE

BIOLOGICAL AND SOCIAL PATTERNS IN THE AUSTRALIAN BULLDOG ANTS OF THE GENUS *MYRMECIA*

By J. Freeland*

[*Manuscript received July* 30, 1957]

Summary

A method of maintaining laboratory colonies of *Myrmecia* F. (Hymenoptera: Formicidae) is described and the results of some hundreds of hours of observation reported.

Small larvae consumed eggs lying nearby in the egg mass with which they were kept, and thus caused gaps in the size distribution of the brood. The workers separated the larger larvae from the egg mass and fed them on insects.

A highly adaptive form of oviposition by workers and queens replaced the regurgitation of many ants, eggs being presented as food to larvae of all sizes or taken by the queen and other workers, sometimes after solicitation. With special exceptions, adult ants or larvae did not consume insects during the winter, though brood cannibalism was prevalent at all seasons.

Behaviour patterns of adult ants are described. There was some division of labour (specialization) partly associated with polymorphism, and the social structure appeared more complex than has been supposed. The lack of advanced regurgitation and development of trophic oviposition in *Myrmecia* is discussed in relation to the evolution of ingluvial feeding in other Formicidae.

I. Introduction

Studies of the Australian bulldog and "jumper" ants of the genus *Myrmecia* F. (Hymenoptera: Formicidae) have been a focal point for investigations into formicid phylogeny. This stems from the fact that the subfamily Myrmeciinae, in which they are included with *Nothomyrmecia* Clark and the fossil genus *Prionomyrmex* Mayr, is regarded as morphologically the most primitive among the ants (Brown 1954).

In many of the more highly social species of ants, adults feed each other and the larvae by regurgitating liquid food from the crop or ingluvies. In the more primitive ants, however, ingluvial feeding is either very limited or entirely absent.

Haskins and Haskins (1950) gave a general account of the habits of several *Myrmecia* spp., and developed the concept that less distinct social patterns existed in *Myrmecia* than in most other ants, their behaviour thus being as primitive and as generalized as their morphology. These authors believed that workers of *Myrmecia* spp. could not transfer ingluvial food to females, larvae, or other workers.

More recently Haskins and Whelden (1954) established that a form of liquid feeding did exist in some *Myrmecia* spp., having observed the process of imbibing by larvae and the passing of liquid food between workers, and demonstrated the transfer of dyed honey from workers to larvae. These processes were unaccompanied by the excitement and typical soliciting behaviour observed in representatives of the

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*19 Central Av., Como, N.S.W.

Formicinae, Dolichoderinae, and Myrmicinae, and the authors stated that, although the frequency of occurrence varied from species to species within *Myrmecia*, the behaviour pattern was crude and limited.

The present work, which extends that of Haskins and Haskins (1950) and of Haskins and Whelden (1954), supports many of their general findings and adds observations on a totally different form of food transference of frequent occurrence which, it is considered, open up a new field for speculation and research. Other adjustments to current concepts of the social structure of colonies of the genus *Myrmecia* are also shown to be necessary.

II. Material Studied

Colonies of several species of ants were maintained in laboratory nests, but the most extensive studies were carried out on single colonies of *M. forceps* Roger and *M. gulosa* (F.) (see Plate 1).

The *M. forceps* colony, consisting of 49 workers, one queen, and six small larvae, was taken in open sclerophyll forest at Sandy Point, Georges R., near Menai, N.S.W., on April 16, 1954. The nest entrance hole was near a stone surrounded by excavated soil "decorated" with forest floor debris, but without a conspicuous mound. This colony was still active in September 1957.

The *M. gulosa* colony was taken on July 21, 1955, from a nest at Como, N.S.W. The nest was surmounted by a mound about 2 ft in diameter, characteristic of the species when nesting in sandy, level soil in open sclerophyll forest. Approximately 115 workers and a similar number of larvae of various sizes were collected. The queen and many workers, including most of the nanitics, were left in the natural nest. Most of the ants taken from this colony were still under observation in April 1957.

III. Equipment and Methods

(*a*) *Type of Formicary Used*

The formicary (Fig. 1) combined features of a vertical nest used by Huber (Wheeler 1910) and a cage by Schneirla (1944*a*) for *Eciton* spp. It should be suitable for most large ants.

It was desirable that ants should be able to leave the nest proper to forage and air themselves under conditions as near as possible to those in nature. Since *Myrmecia* spp. will swim readily, the moat systems of Swammerdam (Wheeler 1910), Lubbock (1894), and others would not confine them. The formicary used comprised a nest cavity between an outer, almost vertical pane of glass and an inner wall of stiff board. Strips of wood at the bottom and sides allowed a space of $\frac{3}{8}$–$\frac{1}{2}$ in. for larger species such as *M. gulosa* or *M. forceps*, but thinner strips ($\frac{1}{4}$ in.) were used for smaller species like *M. fulvipes* Roger or *M. pilosula* Smith. The nest cavity was filled with soil supported on staggered horizontal wooden cleats fixed to the backing. After much of the soil had been excavated by the ants, the cleats provided resting places for the brood.

The glass pane extended above the top of the nest area as part of the front of the cage, the floor of which was level with the top of the nest cavity. The cage was fitted above and behind the nest cavity, and was supported by struts.

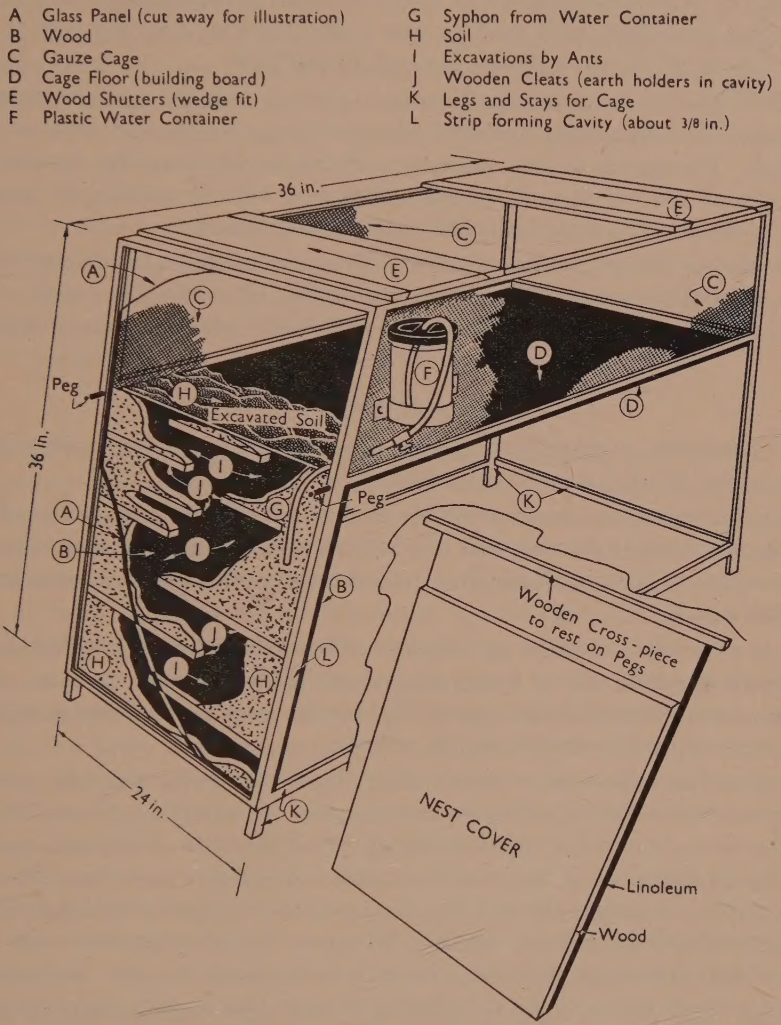
A Glass Panel (cut away for illustration)
B Wood
C Gauze Cage
D Cage Floor (building board)
E Wood Shutters (wedge fit)
F Plastic Water Container
G Syphon from Water Container
H Soil
I Excavations by Ants
J Wooden Cleats (earth holders in cavity)
K Legs and Stays for Cage
L Strip forming Cavity (about 3/8 in.)
36 in.
E
C
A
C
E
C
D
F
c
D
Peg
H
Excavated Soil
36 in.
I
J
G
Peg
K
A
B
I
B
Wooden Cross-piece to rest on Pegs
L
J
I
H
H
24 in.
K
NEST COVER
Linoleum
Wood

Fig. 1.—Diagram of observation nest used.

Sliding shutters between battens on top of the cage gave access to the interior. The glass wall of the nest cavity was darkened by an opaque cover of linoleum reinforced outside by wood. This was removable to permit observations. The linoleum extended the full height and width of the nest cavity, but the wood ended 3 in. from the top. This produced a temperature gradient when, during the winter, the nest was placed in the oblique rays of the sun, as the board prevented the warming of most of the nest cavity to the same extent as the portion covered only by linoleum.

The formicaries were always kept under a roof to prevent flooding by rain. During the warmer 9 months of the year they were also kept in the shade to prevent overheating. They varied in size from one, for colony-founding queens, with a pane of glass 12 by 10 in. and a cage 10 by 5 by 4 in. high, to that used for the *M. gulosa* colony, with a pane 20 in. wide by 26 in. and a cage 3 ft 6 in. long by 2 ft wide and 14 in. high. Observations were always made in diffuse light.

Individual ants could be seen leaving and re-entering the nest and foraging in the cage, and their behaviour observed when returning to the nest with nectar and insect food. Emergence or non-emergence of the female could be checked under conditions more natural than if the extranidal area were covered by glass, as with the nests of Fielde (Wheeler 1910), Brian (1951), and others.

The almost vertical nesting space affords a cross section more closely comparable with natural excavations than horizontal nests. All parts of the interior can be observed with the exception of small areas where soil adheres to the inside of the glass.

(*b*) *Maintenance*

The cages were supplied three or four times a week with honey. On most days insects or other Arthropoda were placed in the cage.

Initially, water was made available through a wick from an inverted bottle. Later, a 4-mm plastic tube was used as a siphon with a regulating cock attached to provide one drop of water each 15–30 sec into the nest cavity from a covered container outside the cage.

Nests were twice invaded by numbers of the dolichoderine ant *Technomyrmex albipes* Smith which raided the honey supply and killed *Myrmecia* workers. Further incursions were prevented by an insecticidal barrier around the pedestal supporting the formicary, or by standing its legs in a moat.

On three occasions—once with a *M. fulvipes* and twice with the *M. forceps* colony—worker ants died of a disease, sometimes at the rate of about one per day for weeks at a time. Symptoms of this complaint were paralysis of anterior appendages followed by an extension of this condition until the posterior legs were affected and death occurred. Following the addition of a trace of potassium permanganate to the water supply, and more frequent supply of honey, no further deaths occurred; but the *fulvipes* colony, untreated, died out. Later, one drop of 2 per cent. mercurochrome was added to each gallon of water instead of the potassium permanganate solution.

(*c*) *Frequency of Observations*

Observations were made almost daily, often several times a day, and frequently at night. They lasted up to 3 hr continuously. Over 600 recorded observations were made on the *M. forceps* colony, and over 350 on *M. gulosa*. Many other, unrecorded, observations were also made.

IV. Diet and Size Grouping of Larvae

Haskins and Haskins (1950) reported that insects were taken into the nest by *Myrmecia* spp. as soon as young larvae appeared, while Haskins and Whelden (1954) described the ingluvial feeding of larvae.

During the present study, observations on mature colonies of *M. fulvipes*, *M. forceps*, and *M. gulosa* and colony-founding females of *M. gulosa*, *M. pilosula*, and other *Myrmecia* species indicated that even in summer larvae were not fed with insects until they attained a quarter—more often a third—of their full growth. Moreover, the only instance of workers feeding larvae from their mouths occurred in a colony of *M. fulvipes* when the workers drank water which had spilled into the dry nest soil, and applied their mouths to those of the small to medium larvae. A small drop of clear fluid, presumed to be water, appeared at the point of contact, the mouthparts of both workers and larvae working within the droplet until it was consumed, presumably by the larvae. The observation nest used for this species permitted the ants to hide, and possibly this behaviour occurred more frequently but escaped detection. It was, no doubt, similar to the behaviour described by Haskins and Whelden. It was not seen in *M. gulosa* or *M. forceps*. Subsequent studies on a second *M. fulvipes* colony failed to reveal this behaviour, even when the colony had been deprived of moisture and then re-supplied with water.

(*a*) M. forceps

The larvae, by swaying their tapering anterior segments and head to one side, could use their own weight to cause them to roll over in the nest chambers and thus, to a very limited degree, reach food with which they had not been directly presented. Larvae often swayed their heads when food was brought close by. This suggested an ability to smell but in warm weather similar movements sometimes occurred in the absence of food. Normally in all *Myrmecia* spp. studied, the food was supplied directly to larvae by the workers in the several ways described below.

Larvae tended to be kept in batches according to size. When all stages were present, there were usually three size groups, though medium larvae were not always separated from large. The segregation of small, possibly first instar larvae from the larger group was almost complete. Small larvae were allowed to remain in the egg mass after hatching. The larger larvae were normally separated from the eggs.

The consumption of nearby (accumulated) eggs by small larvae was usual. Larvae were sometimes assisted by workers—often nanitics—which held eggs in their mandibles, turning them so that the larvae were better able to insert their heads through the torn chorion and consume the contents. A tough, broken shell remained, as when a larva hatches. This is significant in view of observations described below.

When present, the yellowish, more mature eggs were usually eaten first. Otherwise, freshly laid eggs were sometimes consumed. This resulted in a discontinuity in the size range of larval batches even when the female appeared to oviposit continuously (cf. Brian 1951: *Myrmica*).

The consumption of nearby eggs was insufficient to account for the growth of small larvae, and, since insect food was not supplied to them, it was obvious that there was some other source of food which was, in fact, observed and is described below.

Larger larvae were usually fed copiously with insects, though at times these were withheld by workers even when larvae swayed their heads, which usually indicated a readiness to feed on the part of larvae. On the other hand, workers were often seen to disturb resting larvae and thrust insects at them until the larvae inserted their mandibles into the softer tissues. Insects were normally proffered whole, workers sometimes assisting in breaking these up after larvae had eaten the connecting tissues.

Large larvae were seen to roll over with the weight of an insect into which they had thrust their heads, and in this way sometimes fortuitously to share the food with those nearby. Adults were often seen eating from the same insect cadavers as larvae. Workers withheld freshly stung insects in a distant part of the nest for at least a quarter of an hour before supplying them to the brood. There was some brood cannibalism in this colony, but only one dead adult worker was known to be eaten. It was fed to larvae.

Both larvae and workers frequently ate larvae or prepupae and pupae extracted from the cocoons by workers, even though a variety of insects such as moths, flies, beetles, and grasshoppers, normally acceptable as food, were constantly supplied, as was dilute honey.

During winter, adults were never seen to eat the insects abundantly supplied, but in the first winter in this colony they devoured all of the six, small, over-wintering larvae. The larvae had hatched in autumn and showed no evidence of growth once winter set in. When they reached the size at which summer larvae had been fed insects they were not offered any by workers. In the second winter, medium larvae were also present and only one of the nine larvae was eaten. As this activity occurred in the darkened nest, it is unlikely that it was governed by day length. Temperature would be the more likely controlling factor.

(*b*) M. gulosa

The above descriptions of the observations on *M. forceps*, including the failure of adults or brood to eat insects supplied during the winter, applied equally well to *M. gulosa* with only minor departures. These were:

(i) As in *M. forceps*, small larvae were consistently mixed with, or placed near, eggs. They were frequently seen curled around eggs as though consuming them, and the egg mass dimished far more rapidly than could be accounted for by hatchings. This suggested that small larvae ate nearby (accumulated) eggs, as in *forceps*, but contrary to experience with that species the empty shells were not seen in the egg mass.

(ii) Workers were not seen assisting small larvae to consume accumulated eggs.

(iii) It was not established that mature eggs were usually eaten in preference to others.

(iv) In winter, little size segregation of larval groups was apparent. Even in spring and summer, there was less clear-cut size segregation than in *forceps*, and small larvae were sometimes placed in two subdivisions according to size, only the very smallest as a rule remaining with the eggs.

(v) Discontinuity in larval size range was much less apparent. (There is probably a relationship between items (i)–(v).)

(vi) Only about half the over-wintering larvae were eaten. When the colony was taken in midwinter, larvae ranged from small to large, and approximately equalled the workers in number.* At the commencement of spring the ratio was about two workers to one larva. Some larvae had remained fat without growing appreciably, whilst others showed varying degrees of shrivelling. Workers were seen to eat shrivelled larvae, and to present them to other larvae as food. Some healthy looking larvae were also consumed. Food and water had been abundantly supplied.†

These comparisons are best considered against the following background:

The *M. gulosa* colony was devoid of a queen; the eggs referred to were all laid by workers and may not have had a chorion as strong as those laid by queens. It was much larger numerically than the *forceps* colony (which possessed a queen) and was housed in a larger observation nest. Observations on the *M. gulosa* colony were thus less concentrated, being spread over a larger field of vision.

As in *forceps*, the workers tended to place larvae in three size groups, but in both species the separation was often incomplete.

Negative evidence is of value because of the large number of observations.

V. WORKER OVIPOSITION AS A TROPHIC FACTOR

In addition to, and wholly separate from, the consumption of accumulated eggs by nearby small larvae, a highly adaptive form of worker oviposition was regularly observed in both *Myrmecia* colonies, and served as a method of food transference.

(*a*) M. forceps

Workers laid soft eggs and extracted them with the tips of their own mandibles, doubling the gaster forward under the thorax to do so, the sting hingeing towards the dorsum of the gaster to permit the passage of the egg. As the egg was delivered, it was generally pulled and pinched into an irregular, though elastic, droplet of whitish to clear viscous matter which sometimes appeared to be confined merely by surface tension.

Ovipositing workers then approached larvae of any size and held the egg to the larval mouths by the tips of their mandibles. Larvae punctured the surface of the egg material with their mandibles and consumed it in from one to several minutes, the egg material forming a globule about the heads of the larvae. If larvae were resting, the workers often disturbed them with their fore legs and thrust the eggs at them until they began feeding. Other workers or the queen frequently took the egg from the donor's ovipositor with their mouthparts, and consumed it before it could be delivered in the normal manner. At other times also, adults took the eggs with their mouthparts, from the mandibles of the donor.

*Field observations suggested that, in both species, over-wintering larvae may be larger in nature than in the artificial formicary.

†Larvae crawled on their dorsa, like fly maggots, but rarely, slowly, and for only short distances.

Ovipositing workers did not appear to seek a "reward" in the form of exudations from the recipients. The presentation of the egg to a larva or the queen, or its removal by another adult appeared, however, to be an invariable sequence to oviposition by workers, which sometimes proceeded from one larva to another until the egg was accepted. This acceptance seemed to be an end in itself. Adults frequently licked brood or other adults, but this appeared to be quite unrelated to the above pattern, except that remnants of egg material on its recipients were sometimes licked off by adults—usually other than the donor. Workers at times shared eggs with larvae; or larvae, eggs with other larvae. During only two out of many observations were workers seen to share in the consumption of their own eggs. The normal pattern of donor behaviour was: (i) oviposition; (ii) presentation or relinquishing of the egg; and then (iii) apparent disinterest except for attention to its toilet, usually with special attention to the gastral apex.

Worker eggs varied from almost entirely fluid, elastic drops to, in rare cases, firm-looking subspherical eggs like those of the queen. Nevertheless, when the egg material was consumed, no trace of a shell was ever seen. It will be recalled that this was not so following the consumption of accumulated eggs, which had a distinct shell. The accumulation of workers' eggs in the egg mass was not detected.

Larvae were not seen to consume eggs of any sort during winter.

(*b*) M. gulosa

The consumption of worker-laid eggs in *M. gulosa* followed the same basic pattern, with some interesting variations.

During winter, though larvae were not known to be fed with eggs, workers (except in the coldest weather) frequently solicited eggs from other workers and ate them: a worker would approach another and, placing its mandibles above those of the potential donor, begin plying its mandibular tips with the palps, simultaneously tapping or stroking it about the head with the antennae. The passive worker, after a variable period of such stimulation would begin flexing its gaster ventrally, more or less rhythmically, until it was curved well forward under the thorax. The egg material began to emerge and was taken, often before it completed its passage, by the soliciting worker, or sometimes by a third individual. When the egg began to appear, the solicitor, or any other workers nearby, usually showed increasing excitement, and one would take the egg material with her mouthparts, often pulling it into a kidney- or banana-shaped blob. After delivery, the egg sometimes remained in this shape, a "skin" forming.

The egg was generally consumed in one to three minutes, or longer. At times, however, the egg was dropped. Such partly devoured eggs were occasionally allowed to accumulate in the egg mass.

At times the egg material was colourless and emerged from the ovipositior in a soft, rod-like form. Eggs showed all gradations from this viscous liquid to the firm, normal-looking type of egg. There is therefore no doubt that all such matter was egg material. Eggs of *M. gulosa* workers were more variable than those of *forceps*.

At one stage about 500 eggs accumulated in the egg mass, even though workers and brood were feeding freely from eggs which never reached the site of the accumulation.

Workers' eggs in *M. gulosa* were never subspherical as those of *forceps* workers sometimes were. When well formed, they were elongate, one axis being about twice the length of the other. They varied in size considerably, some being twice as long and wide as others. *M. gulosa* queens (studied separately) laid ovoid eggs. Many larvae grew from worker-laid eggs in this queenless colony and over 90 finally emerged as callows, all being males.

The solicitation of eggs was frequently observed in the cooler part of the year, but was rarely seen in the warmer eight months and then generally at night. In warm weather, workers apparently oviposited freely without such stimulus, but in winter, oviposition had generally to be "triggered" by this process. The pattern could be said to appear strongly motivated, both on the part of the solicitor and the donor. The antennal stroking and tapping by the solicitor about the head, and palpation of the mandibles of the prospective donor often occurred without leading to oviposition, both workers striking an attitude suggestive of intense collaboration, maintained for several minutes before it waned and the activity ceased. When the process led to oviposition, the body movements indicated continued tonus of the donor until oviposition occurred. The donor then remained immobile with the gaster curved forward for up to several minutes until the excitement subsided before cleaning itself and wandering away. As in *forceps* the donor appeared to require, as a response, only the removal of the egg by its recipient.

Larvae were fed eggs by workers (see Plate 2) after the manner of *M. forceps*.

(*c*) *Comparison of* M. forceps *and* M. gulosa

No solicitation for eggs by workers in the *forceps* colony was observed, even in winter, though as indicated earlier, workers took eggs from others when they were laid spontaneously in summer. Antennal stroking and palpation of mandibles was seen only twice. It was brief and rudimentary rather than well developed as in *M. gulosa*. However, solicitation by the *forceps* female did occur and it is important to note that all workers in the *forceps* colony during the winter were young, the older workers having died. It is possible that these yearling workers had not yet developed solicitation.* Nanitic workers of both species were seen to oviposit—even firm large eggs—and to feed larvae and adults with these.

VI. BEHAVIOUR OF FEMALES

(*a*) *Queens in Established Colonies*

The queen in the *M. forceps* colony, apart from the well-developed thorax and slightly bulkier gaster, was not appreciably bigger than the largest workers. It was never seen to leave the nest, indeed was not seen above its lower third, though

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*Successful egg solicitation between workers has been seen once in a second (mature) colony of *M. forceps*.

observations were frequently made at night as well as regularly during the day. It was generally relatively close to the brood. Even in winter a temperature gradient in the nest failed to induce her into the upper chambers for warmth, though brood and workers were sometimes seen there.

The queen sometimes licked the larvae and picked them up or turned them over, and was once seen to oviposit, and present the egg to a larva. Oviposition by the queen was observed several times. The general pattern was as follows:

The queen straddled the nest cavity an inch or so above the eggs, flexed the gaster forward ventrally, half-straightened it a few times, and hinged the sting towards the gastral dorsum to permit the passage of a firm-looking subspherical egg. This was delivered with the tips of the mandibles and dropped among the other eggs, after which the queen performed toilet operations and wandered away. No workers were immediately near, or seemed to notice this procedure.

Once the queen laid a soft egg, walked to a larva, and held the egg to its head. The larva inserted its mandibles into the egg material and began consuming it. A worker then approached and began tapping the queen with its antennae. The worker oviposited, after reciprocal tapping from the queen. The egg, which appeared mis-shapen and soft, was taken by the mouthparts of the queen from the gaster of the worker. The worker licked the apex of its own gaster and moved away. By this time the larva had finished consuming the queen's egg and no trace of a shell was seen. The queen consumed the egg of the worker in the course of seven and a half minutes. The egg material adhered to her palps during the process.

The queen was never seen to eat anything other than eggs laid by workers. In winter and early spring she solicited these after the manner described for *M. gulosa* workers. In late spring, summer, and autumn workers' eggs were freely available without solicitation, as shown in an earlier section. However, the queen frequently drank water spilled into the nest.

(*b*) *Colony-founding Queens*

Two *M. pilosula* females, jointly rearing brood, were seen to feed them with soft egg material after the manner of workers of *M. gulosa* and *M. forceps*.

When two young queens of any one species, including *M. pilosula*, *M. gulosa*, and *M. pyriformis* F. Smith, were placed together in an observation nest, they showed behaviour ranging from hostility to marked "friendliness". When favourably disposed, they indulged in mutual or non-reciprocal palpation of mandibles and rapid antennal stroking. At such times the legs of both ants would be drawn up close to their bodies, and this and an accompanying limpness suggested that the behaviour corresponded closely to the "amorous"-looking behaviour between queens of *M. tarsata* F. Smith, described by McAreavey (1948) rather than the mutual cleaning, which often takes place in the nest.

Even when females fought with each other they rarely used their stings and were generally less aggressive than workers.

On one occasion, a *M. pyriformis* queen which had shared an incipient burrow with another queen of the same species for several months, was seen to grasp her fellow about the constriction posterior to the postpetiole for a period of several minutes, during which the gaster of the "aggressor" curved ventrally from time to time, without the sting emerging. The antennal movements of both insects were consistent with "friendly" rather than hostile behaviour. The behaviour, which was similar to that described below for *M. gulosa* workers, was repeated several times during the observation. Several days later, one of the queens was dead.

In none of these species, nor in *M. tarsata*, *M. nigriceps* Mayr, *M. simillima* F. Smith, or *M. piliventris* F. Smith did colony-founding queens seal up the entrances to their incipient burrows as reported for *M. regularis* Crawley by Wheeler (1933) and Haskins and Haskins (1950). McAreavey (1948) noted that the entrances to incipient nests were not sealed by queens of *M. tarsata*.

VII. Individual and Social Behaviour

Observations on marked ants revealed some interesting data on the habits of individual workers within the colonies.

(*a*) M. forceps

Nanitic workers were normally seen near the brood, and were prominent in its care. They were among the most active in rescuing and drying larvae or cocoons when the nest was inundated by spilled water, and were quick to sting any moths or other insects which blundered into the lower galleries when the removal of the nest cover admitted light to the nest. Cocoons, after inundation, were dried by licking, or by banking earth upon them. A few larger workers were equally concerned with such nursing duties and one, a cripple, specialized for some time in the care of cocoons, several times being seen to assist callows to emerge by seizing the caudal end of envelopes whilst the callows struggled from the other, through a rent previously made by the small, apical, mandibular teeth of the worker. Other ants, large and small, took part in this activity but not as consistently. At times workers assisted callows to emerge by pulling at their heads, as indicated by Haskins and Haskins (1950).

Nanitics, though normally in the lower chambers, could be made to dash past larger workers to emerge from the nest by blowing into the nest entrance. They still refrained, however, from foraging while there were larger workers which would do so.

All ants seen foraging in the cage, day or night, were marked. Before the reduction of the population these comprised only about 25 per cent. of the workers, the remainder never being seen above the lower third of the nest.

Workers which foraged regularly were also amongst the most active in general intra-nidal duties, but they spent a good deal of time in the upper nest chambers.

The progressive loss (from disease) of these workers apparently forced less active workers, as well as the crippled ant referred to above, to forage, and eventually the several nanitics were forced to do so. Presumably, hunger stimulated the foraging activity. The female still remained in the lower nest. Yearling workers were eventually obliged to forage. When only 13 workers remained, seven were marked as showing sometime emergence.

In contrast with the pattern seen in older workers, young workers, when they oviposited, tended to remain quite still, holding their eggs in their mandibles for periods of up to 10 minutes without offering them either to brood or adults. Progressively, however, they came to seek out the queen to feed her. They were not seen to oviposit whilst still callow in appearance nor to indulge in social activities other than occasionally licking or moving the brood. They were not known to emerge from the nest until at least 1 month old. Most were considerably older than this at their first emergence while some never emerged at all.

Ordinary licking of each other by workers and female and of brood by adults was prevalent, though unrelated to other trophic processes. Workers occasionally pinched larvae sharply in the manner described by Haskins and Haskins (1950). Sometimes, though not always, they then licked them. Just as often, the licking was done only by workers other than those which had pinched the larvae.

(*b*) M. gulosa

In the *gulosa* colony there occurred forms of intimacy worthy of special note. Apart from ordinary licking and cleaning, and the stroking and soliciting behaviour mentioned earlier, workers at times grasped with their mandibles any part of the bodies of other workers and held them for up to a quarter of an hour. There was no sign of a struggle, the pair simply remaining for the most part motionless, even though other workers passed close by. Occasionally, another would in turn grasp the grasper, and once two workers were suspended chainwise from a third in the nest cavity. At times the gaster of the grasping worker was seen to move up and down slightly in a rhythmic fashion and sometimes to curve well forward ventrally and remain there. The grasping with mandibles and gastral movements were similar to preparation for stinging, but the antennal movements (as with those described above for *pyriformis* females) were consistent with peaceful behaviour. Further, the sting did not emerge. Like the stroking behaviour, the grasping activity ceased almost entirely with the onset of spring, being seen in summer, on rare occasions, at night or in humid weather. This behaviour was not noticed in the *forceps* colony. McAreavey (personal communication) observed its occurrence in workers of *M. tarsata*.

The behaviour of nanitics of *M. gulosa* and proportion of workers habitually foraging appeared much the same as in *forceps*, though nanitics did forage on rare occasions in the *gulosa* cage when plenty of larger workers were doing so.

M. gulosa appeared to be a much more active and more aggressive species than *forceps* and the social interplay more intimate between members of the colony. *M. gulosa* callows appeared to colour more rapidly and became more active sooner than those of *forceps*. In both species the spinning of cocoons as described by Haskins and Haskins (1950) was observed, including the banking of earth about the spinning larvae by workers, facilitating the shaping of the cocoon.

Larvae began spinning about their middle and worked toward their heads. They then turned end-for-end in the half cocoon and completed the other half, again working from the middle. They were seen to turn again a number of times before the envelope became opaque.

VIII. Discussion

(a) *Brood Care and Polymorphism*

In view of the work on polymorphism by Brian (1954, 1955*a*, 1955*b*, 1956) and Wilson (1953, 1954) further work on the results of larval segregation, of discontinuity of larval size due to egg consumption, of brood cannibalism, and of over-wintering is desirable.

(b) *Egg Presentation*

Though egg consumption is common in ants, the only other accounts of the actual *presentation* of eggs to larvae by adults are those by Huber (Wheeler 1910) concerning *Atta* species, of Brian (1953) regarding *Myrmica rubra* L., and of Wilson and Durlach (personal communication) in *Pogonomyrmex badius*. Colony-founding *Atta* females are described as thrusting eggs into the mouths of larvae, and workers as doing likewise with the queen's eggs. This behaviour is said to cease, however, when the fungus garden is sufficiently developed to supply nutriment to the entire colony.*

The process in *M. rubra* and *P. badius* more closely resembles that in *Myrmecia*. This has been discussed with Brian (personal communication) and with Wilson and the observations on *Myrmecia*, *Myrmica*, and *Pogonomyrmex* are compared in Table 1. Solicitation for eggs has not previously been recorded, for any ant.

(c) *Evolution of Ingluvial Feeding*

An interspecific variation of kind or degree in the intra-nidal feeding habits of *Myrmecia* species is indicated both by the work of Haskins and Whelden (1954) and the present results. It seems that feeding from the mouth coexists in the genus with the trophic oviposition pattern herein described.

Dissection of specimens of *M. forceps*, *M. gulosa*, *M. pilosula*, and *M. brevinoda* Forel revealed a large thin-walled sac laying anterior to the proventriculus. Whelden (personal communication), however, considers that this does not necessarily imply the existence of ingluvial feeding. He also has found the crop in *Myrmecia* spp., but has extended this work to all the subfamilies and to a good many genera, including some, like certain *Amblyopone* spp., the workers and females of which seem to be entirely entomophagous. Haskins (personal communication) has kept species of this genus in the artificial nest continually for 32 years and has not observed ingluvial feeding, nor been able to trace it with dyes. Yet there is a fairly well-developed crop in these species also. Whelden considers that the crop may conceivably function in some ants simply as a reserve container for food ingested by the individual for its own use. The statement by Haskins and Whelden (1954) that the ingluvial feeding which they observed showed none of the characteristics of the regurgitation of the higher ants is not inconsistent with the author's impression of the liquid feeding of larvae by workers of *M. fulvipes*.†

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*It has recently been shown that the large alimentary eggs laid by *Atta* females are formed in the ovariole by fusion of two or more reproductive eggs (Bazire-Benazet 1957). A similar process may account for the variability of alimentary eggs of *Myrmecia*.

†Preliminary studies on a second colony of *M. fulvipes* have shown this species to freely practise trophic oviposition. It is possible that what appeared to be the transference of water by mouth was really the sharing of clear egg material by workers and larvae, after workers had laid this without its being observed.

TABLE 1

Myrmecia forceps and *M. gulosa*	*Myrmica rubra*	*Pogonomyrmex badius*
First-instar larvae remained in the egg mass where they hatched and ate nearby eggs. In *M. forceps* (but not necessarily *M. gulosa*) larvae consumed the most mature eggs first. *Accumulated* eggs and fresh worker-laid eggs were often presented to them by workers	First-instar larvae remained in the egg mass after hatching, consuming nearby eggs, but the *newest* first	First-instar larvae remained in the egg pile, where they were observed feeding on worker-laid eggs given them by workers. They were not observed feeding on queen-laid eggs in the egg pile, but observations in this respect were incomplete
Medium-sized larvae were removed from the egg mass and fed insects and presented with only freshly laid eggs which did not reach the egg pile. Regurgitation was not seen. It was, however, reported for some *Myrmecia* spp. by Haskins and Whelden (1954)	In the second instar, larvae were removed from the egg mass and fed with regurgitated food	Medium larvae were removed from the egg pile and fed worker-laid eggs as well as insects and pieces of seed germ. Regurgitation between adults or between adults and larvae was never observed
Large larvae were treated like medium larvae (see above)	Large larvae were fed whole insects and worker-laid eggs, but not eggs from the egg mass	Largest larvae treated much the same as medium larvae (see above)
Solicitation for eggs was common among adults in winter	Solicitation for eggs was not seen	Solicitation for eggs was not seen; workers were never observed feeding on worker-laid eggs
Insects were not malaxated; workers not seen to place eggs near food, but fed them to larvae or the queen if they were not taken and consumed by other workers. Queen-laid eggs were normally placed on the egg pile, but, if soft, presented to larvae by the queen	Workers placed eggs on malaxated insect food	Worker-laid eggs were invariably fed directly either to larvae or to the queen. Queen-laid eggs were apparently (observations limited) invariably placed on the egg pile
The female in the mature *M. forceps* colony was not seen to eat anything but fresh worker-laid eggs presented to her by workers—sometimes solicited and taken by her	Females were seen to eat malaxated insect food and eggs, but it is not known whether these were laid by workers	The queen apparently fed primarily on worker-laid eggs given to her directly by the workers which laid them, but she also occasionally fed on insects or seeds brought into the nest

TABLE 1 (*Continued*)

Myrmecia forceps and *M. gulosa*	*Myrmica rubra*	*Pogonomyrmex badius*
With one exception (*M. fulvipes*) ingluvial feeding was not seen in the present study. The liquid feeding reported by Haskins and Whelden (1954) in *M. regularis* appeared rudimentary, though frequent	Ingluvial feeding between workers and between workers and larvae was frequent and well developed	Ingluvial feeding between adults or between adults and larvae was never observed
Workers ate worker-laid eggs which were sometimes mis-shapen, rod-like, often almost fluid	Workers ate worker-laid eggs which were sometimes mis-shapen	Workers were never observed feeding on eggs

In view of the primitive morphology of *Myrmecia* it is likely that egg consumption and trophic oviposition preceded ingluvial feeding. The suggestion is advanced that such egg consumption supported colonial organization whilst the ingluvies evolved, liquid-food sharing commencing as a mere licking of nectar or other food adhering to the mandibles and mouthparts of foraging individuals, then graduating to the spilling of food from the infra-buccal pouch, and thence to ingluvial feeding proper. That ants can and do carry moisture in the infra-buccal pouch is suggested by the account given by Fielde (see Wheeler 1910) of workers of *Aphaenogaster fulva* Roger var. *picea* Em. moistening nest soil. In this respect *Myrmica* may be intermediate between *Myrmecia* and *Pogonomyrmex* on the one hand, and those ingluvial-feeding genera which do not practise solicitation for, or presentation of, eggs. *Myrmica* and *Pogonomyrmex* are regarded as relatively primitive genera.

Brown (1954) expressed the belief that the two subfamilies, Myrmeciinae and Myrmicinae, in which the presentation of eggs to brood has been witnessed, were not closely related. It would be interesting to know if similar behaviour occurs among the primitive genera of other subfamilies.

(*d*) *Causation of Social Behaviour*

When Wheeler (1918) modified the oecotrophobiosis theory of Roubaud and called it "trophallaxis", he emphasized its mutualistic nature. Adult social insects fed one another, or larvae, and in return licked palatable exudates from the bodies of the recipients of the food. Later (1928) he added the possibility of an olfactory, to a gustatory, stimulus and indicated that it was difficult to differentiate between these two chemoreceptive functions.

Brian and Brian (1952), analysing the history of the trophallaxis concept, stated that at this point "the concept began to move away from its initially *cohesive* form towards a *kinetic* form; it no longer described a means of social cohesion, but a method of social activation."

Schneirla (1944*b*) included under the term trophallaxis the stimulation of passing workers (*Eciton* spp.) which was believed to arouse quiescent larvae to squirming activity. The chance bestirring of workers by larvae was also considered trophallactic. Thus, in its broader sense, trophallaxis, despite its derivation, includes almost any kind of inter-individual stimulus for social behaviour.

Judging by the lack of antennal activity or other outward signs, *Myrmecia* adults usually showed no discernible gustatory or olfactory interest in larvae at or about the time when these were fed with eggs. This renders a simple, *mutualistic* trophallaxis inadequate as a cause of such food transference. The prospect of exudations *at some other time* is not likely to prove a strong stimulus. The fact that adults do sharply pinch larvae, and then sometimes proceed to lick them, suggests that exudates may play a part in promoting retention of brood in the nest, but this behaviour was never seen at the time of egg feeding, and only rarely when larvae were eating insects. It generally occurred when no feeding had taken place.

Wheeler (1910) states that the licking by ants protects the bodies of other individuals from lethal moulds and bacteria, and Richards (1953) suggests that a similar function is served by the licking of eggs by earwigs. The fact that licking is common in *Myrmecia*, but usually unrelated to feeding processes, supports the view that exudations may induce such protective behaviour.

Brian and Brian (1952) present experimental evidence to show that, in the wasp *Vespula*, larval exudates were not sufficiently palatable to serve as a stimulus for feeding, and discuss the imbibing of larval fluids by *Vespula* workers as a means of taking away such surplus moisture which otherwise would deteriorate the nest. The need of larvae to dispose of fluids probably became adapted to serve various functions in different insect species. Wheeler (1922) recognized that, in many species of social insects, there was little or no connection between the supplying of food and the imbibing of exudates.

Though food transference serves an important function, this may be unimportant as a basis of social cohesion. Whether or not such a basis is trophallactic in character, a detailed analysis is still required. There is little doubt that nest odour plays an important part (Fielde 1904).

In sexually differentiated animals there is an obvious broader behavioural difference between a solitary and a social species. In solitary species, consociations between adult individuals are intersexual only. In social animals they are intrasexual as well. The forms of "attraction" responsible for such consociations no doubt vary from one species to another, and are probably complex within any one species. This is consistent with the fact that there are degrees of social cohesion, some animals being only partly or intermittently social. Students of social insects seem agreed that these were derived from solitary species. Therefore, the cohesive factors were probably derived from elements present in solitary species in some other form. In Hymenoptera this was no doubt partly associated with the differentiation of the worker caste from the true female, but it should be noted that queens of some species also behave socially toward one another.

A widely accepted idea is that social structures in insects stemmed from an extension of the period of oviposition sequence, causing the mother to be still feeding larvae when her older progeny had reached the imaginal state. This required that "attractions" (social releasers) should have developed between adults *of the one sex*. It may have been a neotenic extension, throughout the entire ontogeny, of the factors making brood acceptable to parents. Alternatively the factors may be adaptations of those bringing opposite sexes together for copulation.

There may be some significance in the impression gained that in *Myrmecia* the forms of bodily contact (palpation of mandibles, antennal stroking, and grasping) occurring between workers, between queens, and between workers and queens seemed intensely motivated. Objective ethological research is needed to determine the components of such patterns and (1) the importance of such behaviour to social cohesion; (2) whether it is autochthonous; and (3) whether it represents behavioural homologues, adaptations, or displacements of the reproductive instinct denied its copulative outlet. When stroking becomes solicitation, and results in trophic oviposition, it may be a secondary adaptation of such an overflow functioning, in the terminology of Lorenz and Tinbergen (Tinbergen 1951), as a social releaser.

The large stature and generalized nature render *Myrmecia* species highly suitable for such a study.

IX. Acknowledgments

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Explanation of Plates 1 and 2

Plate 1

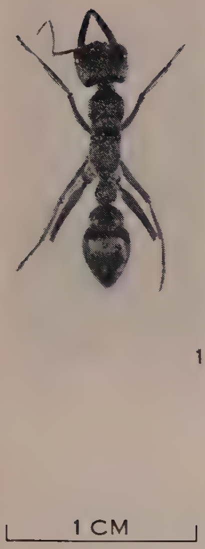
Figs. 1–6.—Ants used in laboratory colonies. 1, *M. fulvipes* Roger. 2, 3, *M. forceps* Roger: 2, major worker; 3, minor worker. 4, *M. tarsata* F. Smith. 5, 6, *M. gulosa* (F.): 5, major worker; 6, minor worker.

Plate 2

Trophic oviposition in *M. gulosa* (F.)

A worker lays egg material (Fig. 1), delivers it with its mandibles (Fig. 2), walks to larva (Fig. 3), holds egg material to larval mouth (Fig. 4), releases it (Fig. 5), and backs away as larva consumes the egg material (Fig. 6). Photographs by Mr. D. Trengove, Randwick, N.S.W.

BIOLOGICAL AND SOCIAL PATTERNS IN ANTS



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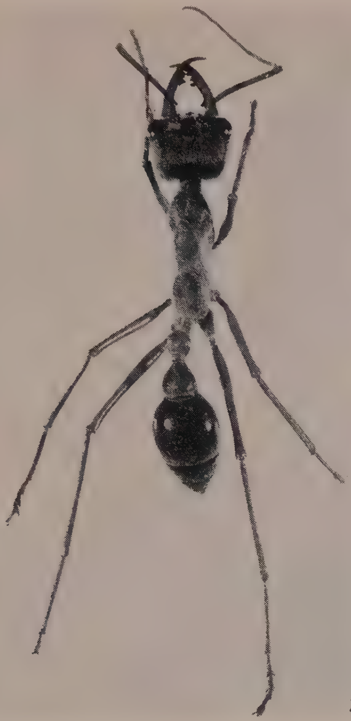

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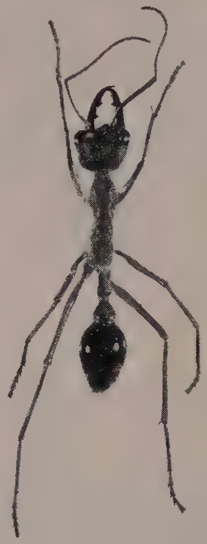

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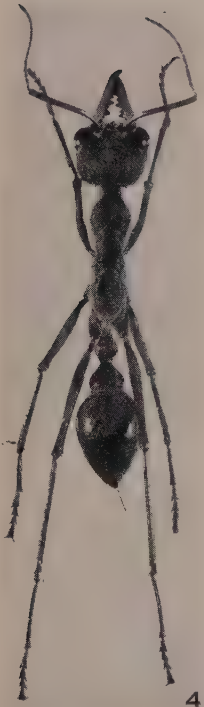

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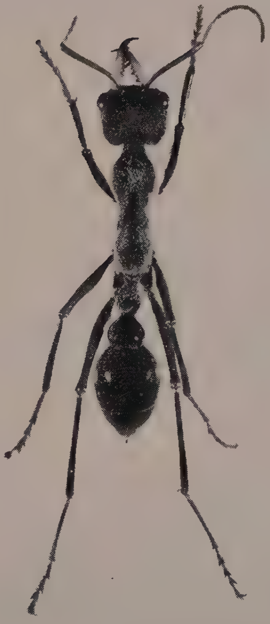

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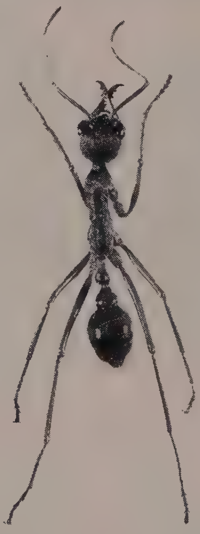

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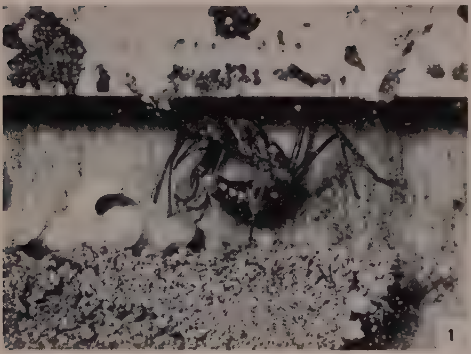

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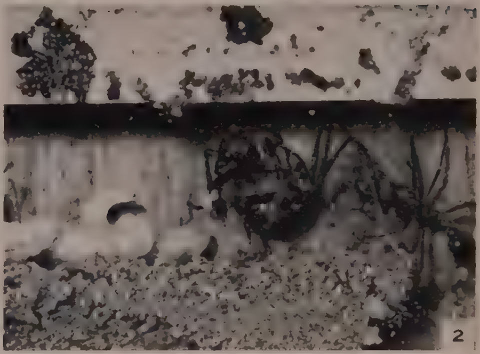

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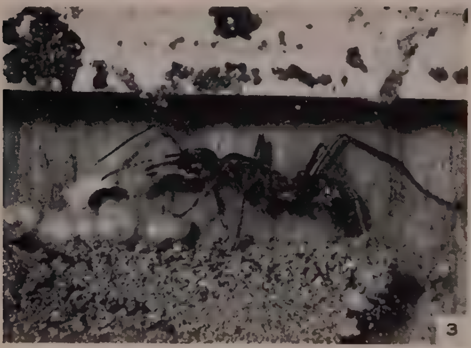

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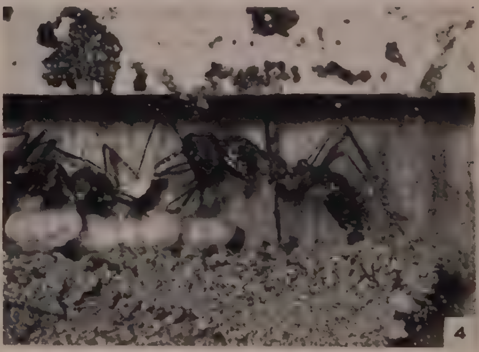

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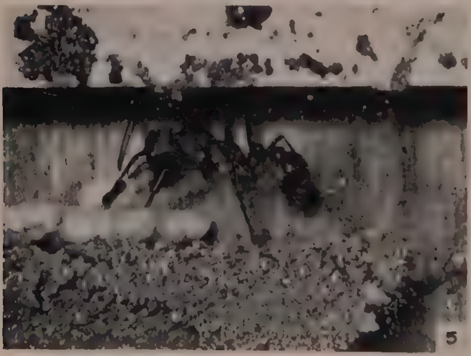

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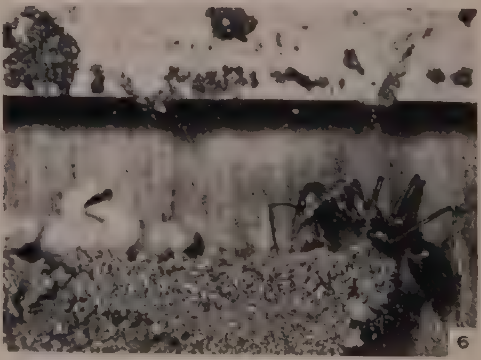

6

THE ECOLOGY OF *ONCOPERA FASCICULATA* (WALKER) (LEPIDOPTERA: HEPIALIDAE) IN SOUTH AUSTRALIA

V. CHANGES IN THE ENVIRONMENT OF O. FASCICULATA ASSOCIATED WITH THE DEVELOPMENT OF COUNTY GREY FOR AGRICULTURE

By P. E. Madge*

[*Manuscript received September* 28, 1957]

Summary

Before County Grey was developed for agriculture, *Oncopera fasciculata* (Walker) probably was restricted by excessive wetness to the higher, drier portions of the poorly drained soils, and by dryness to the lower, moister portions of the well-drained soils. Even in these places the insect probably was not able to maintain large numbers because suitable food was scarce.

Steps in the development of the area for agriculture have included artificial drainage, clearing of woodland and scrub, the use of phosphatic and trace-element fertilizers, and the establishment of pastures consisting of subterranean clover (*Trifolium subterraneum* L.) and other introduced clovers and grasses.

This development has provided a more favourable environment for *O. fasciculata*. Artificial drainage reduced the chances of exposure to excessive wetness, and the establishment of pastures composed of clovers and perennial grasses not only provided protection for the eggs and young larvae against evaporation, but also made available a greater amount of good-quality food for the larvae.

I. Introduction

Thirty years ago, *Oncopera fasciculata* (Walker) was a rare species in South Australia. Now it is much more abundant. The numbers have increased because man, in developing the area for agriculture, has greatly ameliorated the environment of the species.

The present paper first describes County Grey as it probably looked before European settlers arrived. This is followed by an account of the development of the district for agriculture, and how this development has resulted in a more favourable environment for *O. fasciculata*.

II. Natural Vegetation and Physiography

Land found in County Grey may be divided broadly into three main groups: (1) low-lying and exposed to seasonal flooding; (2) well-drained and supporting trees and shrubs, but with little or no grass; (3) well-drained and supporting trees and shrubs, with an undergrowth of grass (Madge 1957, Fig. 1).

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(a) *Poorly Drained Land*

Swamps are plentiful in County Grey even today; they were much more extensive before artificial drainage was started. The natural vegetation associated with swamps varies considerably, for the swamps themselves vary in salinity as well as in soil type. The main plants are ti-tree (*Leptospermum* spp., *Melaleuca* spp.), reeds, rushes, and sedges (Eardley 1943).

Two types of soil are associated with the poorly drained land—the heavy black soils and the sandy soils.

Trees are almost completely absent on the black flats. Some honeysuckle (*Banksia marginata* Cav.) is present but the dominant plant species are white tussock grass (*Poa australis* R. Br.), cutting grass (*Gahnia* spp.), and thatching grass (*Cladium* spp.) (Plate 1, Fig. 1). Honeysuckle apparently was common before the black flats were artificially drained, and Woods (1862) described honeysuckle country as ". . . extensive flats or plains growing little else but coarse rank grass and *Banksia*, covered with water in winter". An idea of the natural appearance of the black flats may be obtained from Woods' description of German Flat, south-west of Tantanoola. East of the dune along the eastern side of Lake Bonney was " . . . a long swamp which runs parallel with the range for the whole length of the lake. It is twenty-five miles long and three wide. Here and there, places may be found where it is passable, but, in general, it is an immense quagmire, thickly covered over with dense reeds".

Red gum (*Eucalyptus camaldulensis* Dehn.) dominates the vegetation on the more fertile sandy soils (meadow podsols). Undergrowth consists of red-gum saplings, *Banksia* spp., *Acacia* spp., and bracken fern (*Pteridium aquilinum* (L.) Kuhn). Native grasses, which are mainly species of wallaby grass (*Danthonia* spp.), are found on the higher banks, and there are sedges and rushes on the wetter land (Plate 1, Fig. 2).

A description of the appearance of this type of country before it was developed by white man is given by Molineux (1883). He said that the district near Penola was ". . . quite a swampy country in wet weather, with good grass wherever the land is slightly elevated. There is a deal of coarse vegetation all over it, consisting of rough grass, rushes, and sedges principally, with plenty of gums".

A sclerophyll-heath vegetation grows on the less fertile, low-lying sands (podsolized sands) (Plate 2, Fig. 1). This country is characterized by a low, stunted vegetation made up mainly of *Banksia* spp., yacca (*Xanthorrhoea* spp.), kidney bush (*Hakea* spp.), oak bushes (*Casuarina* spp.), and ti-tree (*Leptospermum* spp.). Yacca and honeysuckle are dominant on the higher sandy banks. Woods' (1862) description of these sandy plains was ". . . heavy and dusty in summer and boggy in winter, supporting no grass nor any trees but those of a stunted and worthless character, run through, here and there, with belts of short and crooked 'stringy bark' and in all other places covered with tangled brushwood, about two feet high".

(b) *Well-drained Land with little or no Herbage*

Stringybark (*Eucalyptus baxteri* (Benth.) or *E. obliqua* L'Hérit. or both) is the dominant tree on the stranded dunes, where the natural vegetation is a dry sclerophyll forest (Plate 2, Fig. 2). A few small trees or tall shrubs are found beneath the stringybark, the main ones being *Acacia* spp., *Banksia* spp., and native box (*Bursaria* spp.). Bracken fern, *Acacia* spp., yacca, and ti-tree make up the undergrowth. A large proportion of this dune country still remains under natural forest, although in the higher rainfall areas the dunes have been cleared and planted with exotic pines.

Woods (1862) said that the sandy dunes ". . . are nearly destitute of grass, but are very shrubby, rarely supporting any other tree but a stunted and irregular growth of *Eucalyptus Fabrorum*, or stringy bark . . .". He described the dune between Mt. Gambier and Mt. Schank as being " . . . broken and very hilly. The soil, too, is less rich, as evidenced by the quantity of stringybark and grass tree. The ferns and underwood also become thick and intricate". Another sort of sandy situation, found in the south-eastern corner of County Grey, was described by Ward (1869) as ". . . lightly timbered, chiefly with honeysuckle or sheoak and covered with ferns".

When surface limestone is abundant, sheoak, native box, honeysuckle, and *Acacia* spp. are the prominent species. Bracken fern dominates the undergrowth, and grasses are found occasionally.

Sand dunes near the coast have been stabilized by a dense scrubby vegetation consisting mainly of ti-tree, sheoak, sandalwood (*Myoporum insulare* R. Br.), *Acacia* spp., native box, sandhill daisy (*Olearia* spp.), and others (Tiver and Crocker 1951). There is little or no grass.

(c) *Well-drained Land with Herbage*

The original natural vegetation on this land is difficult to determine because it contains the richest soil in the lower south-east and was the first to be cleared for agricultural purposes. Stringybark probably dominated this region, and honeysuckle, *Acacia* spp., and bracken fern would have been abundant (Tiver and Crocker 1951). There would have been a ground cover of grass. Although there are no trees on Mt. Schank today, Grant (1803) described both Mt. Gambier and Mt. Schank as being covered with large trees ". . . as also was the surrounding land, which was low and flat". Angas (1847) described the country around Mt. Schank as ". . . a rich plain, scattered over with luxurian gum and wattle trees".

Early settlers found it difficult to grow crops on the well-drained soils because these became so dry in the summer. Ward (1869) said that the soil around Mt. Gambier was of the "richest character" but that it had one disadvantage: ". . . the subsoil is exceedingly porous, and however much rain may fall, it is so quickly absorbed that the crops, especially those which require moisture late in the summer, frequently suffer materially in consequence". However, where clay underlies the top soil, moisture is not lost so quickly; this sort of place is found in the Yahl area, about 5 miles south-east of Mt. Gambier.

There were grasses on this well-drained country, as well as in other parts of the County, but they were of very poor quality compared with the introduced species found there today. Herbage indigenous to the district is high in fibre and low in proteins, for there are no medics or clovers (Tiver and Crocker 1951).

III. Development of Agriculture

(a) *Settlement by Europeans*

The recorded history of the southern portion of South Australia began in 1800 when Lt. James Grant, R.N., in H.M.S. "Lady Nelson", sighted the southern coast. The first white men entered the district in 1839 (from a cattle station in western Victoria), and were impressed with the grazing possibilities of the land around Mt. Gambier. The first occupation licences for land in the south-east were issued from Adelaide in 1841, and the first pastoral leases were issued 10 years later.

Cultivated crops were produced soon after the pastoral settlement of County Grey, and by 1859 (the first year for which data are available) more than 4000 acres were under cultivation (Boothby 1860). Most of this land was sown to cereal crops (mainly wheat), but potatoes also were grown. The area under cultivation increased during the later part of the nineteenth century; cereals were the most important crop, but potatoes, flax, hops, and tobacco also were grown.

(b) *Improvement of Herbage*

Perennial species of grasses were introduced into County Grey before 1860, and by that year 48 acres were sown to "permanent artificial grasses" (Boothby 1861). These grasses, which were grown at Yahl, included cocksfoot (*Dactylis glomerata* L.), Yorkshire fog (*Holcus lanatus* L.), and perennial ryegrass (*Lolium perenne* L.). The introduced grasses grew well at Yahl but were not satisfactory in other areas; they were not used extensively until about 1923, when it was found that their poor growth was caused by insufficient phosphate. Liberal applications of superphosphate overcame this deficiency. Soon afterwards subterranean clover (*Trifolium subterraneum* L.) was found in the south-east. This legume grew very well on some of the soils and soon became of great importance when graziers realized how productive it was and how easily it became established when adequate superphosphate was applied (Hill 1936).

When superphosphate is added annually to cleared woodland, subterranean clover may become established, as well as other introduced legumes. Following the increased growth of the legumes, native grasses increase in density as more nitrogen becomes available. Continued top-dressing with superphosphate leads to a greater development of subterranean clover, and native grasses are replaced by volunteer annual grasses such as silver grass (*Vulpia* spp.), barley grass (*Hordeum leporinum* Link), and brome (*Bromus* spp.); the perennial grass Yorkshire fog also appears.

The next stage in the development of grazing land in County Grey, which began in the 1930's, was the introduction of perennial grasses into pastures of subterranean clover, and the discovery of legumes for soils where subterranean clover did not grow well. The usual practice now is to sow subterranean clover and one or more of Wimmera ryegrass (*Lolium rigidum* Gaud.), perennial ryegrass, Yorkshire fog, *Phalaris tuberosa* L., and cocksfoot. On soils that are too alkaline or too subject to flooding, subterranean clover is replaced by strawberry clover (*Trifolium fragiferum* L.), which is adapted to a wet environment and will survive several weeks of flooding.

An idea of the increased carrying capacity of sown pastures that are top-dressed annually with adequate superphosphate can be obtained from the statements that native grasslands dominated by *Danthonia* have a carrying capacity of about 0·7 dry sheep equivalents per acre (Cook 1937), while the improved pastures will carry 3 to 6 and more sheep per acre (Stephens *et al.* 1941).

A later stage in the improvement of pastures was the discovery that most soils in County Grey are deficient in one or more of the trace elements copper, zinc, cobalt, and manganese. For instance, the growth of herbage plants was improved when manganese was added to volcanic soils, copper added to terra rossa soils, copper and zinc added to the podsolized sands, and zinc, copper, and manganese added to the peaty soils (Tiver and Crocker 1951).

(*c*) *Artificial Drainage*

Before drains were dug, land between the sand-dune ranges consisted mainly of swamps and lagoons, for the ranges blocked natural drainages to the sea (Madge 1956).

The first mention of the need for drainage to improve land in the lower south-east was in 1863, with the suggestion that cuttings be made through the narrow ridges (Woakwine Dune) separating swamps in the Millicent district from Lake Frome, and a complete survey of the district (Goyder 1863). The first cutting, made in 1863, was 4 ft deep, 12 ft wide, and 528 ft long. This was a relatively minor undertaking, and yet it made some very rich, peaty soil available for farming. The immediate effect of the first cutting was to let off an immense body of water that had covered most of the Millicent district, or had moved slowly to the north-west. Ward (1869) said that "Some of the slight rises on the flats that used to be covered as the waters moved down from the south, were 'reclaimed' and finer grasses appeared as the result . . . and the wet country was improved by the fact of the water being reduced and consequently disappearing so much earlier in the year". It was estimated (Coulthard 1864) that about 50,000 acres of good agricultural land in the Millicent district would be available almost immediately.

Another undertaking was to remove surplus water from swampland in the district around Kalangadoo and Furner. This involved cutting drains to connect with Reedy Creek, and clearing the creek of obstructions. This work began in 1882, and by the latter part of 1884 a hundred miles of channel had been cleared. Molineux (1883) said that ". . . already a very large area of swamps is drained, and where at that time last year (1881) there were miles upon miles square covered with water, upon which all kinds of waterfowl were swimming, there is now a springy mass of dry turf, which rocks almost beneath the tread".

Three cuttings were made at Port MacDonnell during 1863–64 to drain that district, and a main channel (now called Eight Mile Creek) was dug about 1878. It was estimated that about 4500 acres of rich peat land could be drained, but this work was not finished until after World War II.

Other drains dug during 1880–1920 helped to drain the country around Furner and Penola, as well as some of the land in the adjoining County of Robe. The drainage of the northern portion of County Grey was improved when a drain was dug from near Furner to the sea near Robe, in County Robe; this provided a much more direct approach to the sea.

IV. Discussion

Before it was modified by white settlers, County Grey probably was composed mainly of sandy ridges covered with a dry sclerophyll forest, and large areas of flats and plains under water for at least part of the year and carrying rushes and other plants having a coarse, reedy growth. Only a small part of the total area was suitable for grasses, and so the distribution and abundance of *O. fasciculata* was limited by the food supply, as well as the dryness on the sandy ridges and the wetness on the flats and plains (Madge 1957).

The almost complete absence of a suitable food supply, as well as a dry environment during the late spring and summer, probably were the main factors limiting the establishment of *O. fasciculata* on the sandy ridges. In 1955, 173,260 acres of this sort of country were under forest reserves, of which 78,406 acres were planted to exotic pines (mainly *Pinus radiata* D. Don) and the remainder were under natural sclerophyll forest or were ploughed for firebreaks. Land included in the forest reserves is very unfavourable for *O. fasciculata* because no herbage is found under the pines, and bracken fern is the dominant species on the firebreaks; grasses are not usually associated with sclerophyll forests.

In other situations where the soil is well drained (volcanic and terra rossa soils), *O. fasciculata* was not exposed to drowning and there was food available, but the well-drained nature of the soil might have resulted in the eggs and larvae being exposed to evaporation during the late spring and summer. It is likely that the most favourable situations for *O. fasciculata* were where the well-drained soils did not become too dry during the summer. This sort of place might have been where drainage was impeded by such barriers as layers of clay, as is found at Yahl. It is interesting to note that the first collections of *O. fasciculata* in South Australia were made at Yahl, in 1896 (Tindale 1933).

The removal of surplus water from the flats and plains of County Grey has made a large part of this area favourable for the development of *O. fasciculata*. Some of the drained land (especially the black soils) is still too wet for the insect to survive, and in years with wet late winters there is a high death rate over most of the flats and plains. Even so, the species has been able to persist, at least in low numbers, on this land which was almost entirely unsuitable before it was artificially drained.

Each stage in the development of improved pastures in County Grey has resulted in a more favourable environment for *O. fasciculata*. The increased growth of clovers, following the clearing of land and liberal applications of superphosphate, provided the eggs and larvae with a more favourable shelter against dryness and heat. A still more favourable shelter appeared as a result of the growth of grasses being stimulated by the greater amount of nitrogen available. The introduction of perennial species of grasses has resulted in a greater amount of herbage being present during more of the year. The incorporation of trace-element fertilizers with dressings of superphosphate has improved the quality and quantity of pasture species and so also has improved both the amount of shelter and the quality and amount of food available to *O. fasciculata*.

The practice of maintaining permanent pastures in County Grey has provided more favourable places for *O. fasciculata* to live because these pastures are not disturbed by ploughing, and the introduced grasses and clovers produce a dense mat of herbage which provides protection for the eggs and larvae against desiccation.

With these changes in its environment produced by man, *O. fasciculata* is now able to survive over a much wider area and in larger numbers than formerly. Even with a more favourable environment, however, *O. fasciculata* is not a serious pest every year because the relative abundance of the species is determined mainly by weather (Madge 1957).

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Explanation of Plates 1 and 2

Plate 1

Fig. 1.—Native grasses on the poorly drained soils usually have a tussocky habit; here is shown white tussock grass (*Poa australis*) on a heavy, black soil.

Fig. 2.—Natural sclerophyll woodland on a relatively fertile sandy soil. Low-lying land in the foreground is flooded during the winter–early spring but artificial drainage enables this water to drain away by early summer. Red gum (*Eucalyptus camaldulensis*) is the dominant tree on the higher land; wallaby grass (*Danthonia* spp.) is sparsely distributed over this drier land.

Plate 2

Fig. 1.—Typical heath country on the less fertile sandy soils. In the foreground are *Banksia* spp., *Xanthorrhoea* spp., and other vegetation found on the wet flats. In the background, on slightly higher land, are *Eucalyptus baxteri* and associated vegetation.

Fig. 2.—A dry sclerophyll forest on a stranded dune. The tree is *E. baxteri* and undergrowth consists of *Banksia marginata*, *Pteridium aquilinum*, and *Xanthorrhoea* spp.

ECOLOGY OF ONCOPERA FASCICULATA. V

1

2

ECOLOGY OF ONCOPERA FASCICULATA, V

1

2

THE TESTICULAR RETE MIRABILE OF MARSUPIALS

By C. H. Barnett* and C. W. Brazenor†

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Summary

The spermatic cords of 24 representative marsupial species have been examined for the presence of a rete mirabile. In the great majority, a well-developed rete, consisting of many parallel arteries and veins enclosed within fibrous and cremasteric muscle sheaths, was present, and it is suggested that this finding is of some taxonomic value, since no similar structure has been observed in eutherian mammals (Harrison 1949). The functional significance of this rete mirabile is discussed.

I. Introduction

Harrison (1948) was the first to describe a rete mirabile, composed of many parallel arteries and veins, in the extra-abdominal course of the testicular vessels of a marsupial, *Macropus rufogrisea fruticus* (= *Wallabia rufogrisea frutica* Ogilby), and in 1951 he recorded a similar vascular modification in eight further marsupial species. Harrison tentatively suggested that the rete might have taxonomic significance if occurring in all marsupials, since it was not found in any of a large series of eutherian spermatic cords that he had examined (Harrison 1949). The present study was undertaken to ascertain whether a testicular rete is in fact an invariable finding in the Didelphia. It appears from Harrison's work that the rete reaches its maximum development in the Macropodidae (e.g. see Harrison 1949, Plate 1, Fig. 3). The following descriptions concerning other species—in respect of total number of vessels, uniformity of size, and regularity of arrangement—are given relative to that account. In view of MacKenzie's statement (1919) that the cremaster muscle is especially thick in marsupials, the degree of development of the muscle in each spermatic cord examined has also been recorded.

II. Material and Methods

Representatives of most Australian marsupial families were examined, as listed in Section III. Many specimens had been preserved in spirit for long periods at the National Museum of Victoria and were unsuitable for vascular injection. However, latex or indian ink injection of the arteries was carried out in fresh specimens of two species, *Trichosurus vulpecula* Kerr (brush-tail possum) and *Pseudocheirus laniginosus* Gould (common ring-tail). The extra-abdominal portion of the spermatic cord, including the cremasteric muscle coat, was dissected out and sectioned transversely. In some smaller marsupials it was found more convenient to cut sections of both cords, within the covering skin, since in these animals the scrotum is freely suspended from the abdominal wall by a slender tube of skin containing the two cords, the whole resembling the clapper of a bell. The vessels present in each section were counted and an average value determined. Unless otherwise stated, at least two cords of each species were examined. For comparison, some of Harrison's data are appended to Section III.

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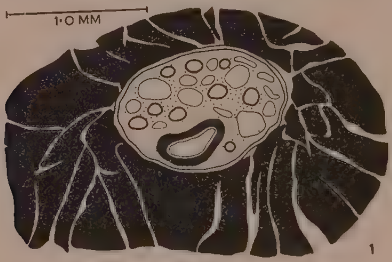
III. Results

Family Dasyuridae

Dasyurops maculatus Kerr (tiger-cat).—Well-defined rete present, containing 20 arteries and 15 veins regularly intermingled. The vascular bundle is enclosed within a thick fibrous sheath, surrounded by a very thick, complete, cremasteric muscle coat.

Dasyurus quoll Zimmermann (eastern native cat) (Fig. 1).—Pattern similar to *D. maculatus*. 11 arteries, 12 veins.



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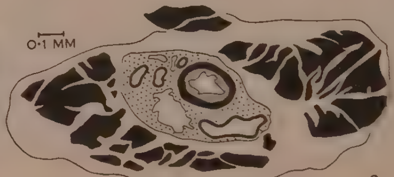

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Fig. 1.— Spermatic cord of *Dasyurus quoll*. In this and subsequent figures the cremaster muscle and the muscular wall of the vas deferens are black, and connective tissue is coarsely stippled.

Fig. 2.—Spermatic cord of *Sminthopsis crassicaudata*.

Dasycercus cristicauda Krefft (crest-tailed pouched mouse).—Well-defined rete. Fibrous sheath thin; cremasteric coat exceptionally thick. 12 arteries, 9 veins.

Phascogale tapoatafa Meyer (brush-tailed pouched mouse).—Vessels multiple but not very regularly intermingled. Fibrous sheath thin; cremaster very thick. 8 arteries, 4 veins.

Antechinus swainsonii Waterhouse (dusky marsupial mouse).—Rete poorly developed, not surrounded by fibrous sheath. Very thick cremasteric coat. 4 arteries, 3 veins.

Sminthopsis crassicaudata Gould (fat-tailed pouched mouse) (Fig. 2).—No true rete. Very thin fibrous sheath; thick, loose cremasteric coat. 4 arteries, 3 veins.

Family Myrmecobiidae

Myrmecobius fasciatus Waterhouse (banded anteater).—Only one cord examined. Rete and coverings similar to *Dasyurops maculatus*, but veins collapsed and difficult to count. 14 arteries, at least 9 veins.

Family Phascolarctidae

Phascolarctos cinereus Goldfuss (koala).—Rete present but vessels not arranged in an orderly manner and considerable branching and cross-anastomoses of veins.

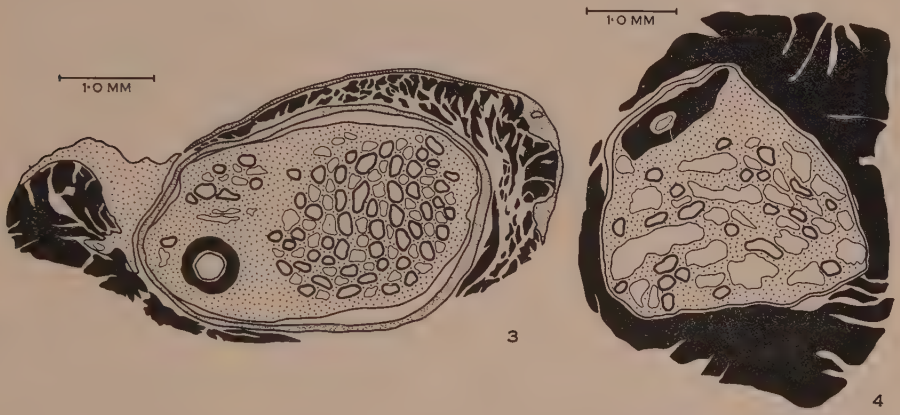
The venous walls are thick, not easily distinguished from arteries. Thin fibrous sheath; very thick cremasteric muscle coat. 53 arteries, 27 veins.

Family Phalangeridae

Trichosurus vulpecula Kerr (brush-tailed possum) (Fig. 3).—Well-defined rete. Latex injections show parallel vessels, branching somewhat in distal fifth of rete, supplying epididymis as well as testis. Thick fibrous sheath; moderately thick cremasteric muscle coat. 49 arteries, 56 veins.

Schoinobates volans Kew (greater possum-glider).—Irregular rete with numerous anastomoses between veins. Moderately thick fibrous sheath; cremasteric coat loose, of uneven thickness. 33 arteries, 23 veins.

Pseudocheirus laniginosus Gould (common ring-tail) (Fig. 4).—Similar to *S. volans*. 24 arteries, 28 veins.



Spermatic cord of *Trichosurus vulpecula* (Fig. 3) and *Pseudocheirus laniginosus* (Fig. 4).

Petaurus breviceps Waterhouse (sugar glider).—Multiple vessels forming an irregularly arranged rete. Thin fibrous sheath; thick cremasteric coat. 8 arteries, 9 veins.

Cercartetus nanus Desmarest (pigmy possum).—Rete as in *P. breviceps*. Irregular fibrous sheath; thick cremasteric coat. 7 arteries, 8 veins.

Acrobates pygmaeus Shaw (pigmy glider).—No true rete—multiple arteries and veins but these very variable in diameter, not intermingled. Fibrous sheath of uneven thickness; cremasteric coat moderately thick. 9 arteries, 7 veins.

Tarsipes spenserae Gray (honey possum).—Rete present though veins very variable in diameter. Thick fibrous sheath; cremasteric coat very thick medially and thin laterally. 10 arteries, 10 veins.

Family Peramelidae

Perameles gunni Gray (Tasmanian barred bandicoot).—Well-defined rete. Fibrous sheath thick; cremasteric coat deficient medially, very thick elsewhere. 23 arteries, 35 veins.

Isoodon obesulus Shaw & Nodder (short-nosed bandicoot).—Rete as in *P. gunni*. Fibrous sheath of uneven thickness; cremasteric coat thin medially, very thick laterally. 29 arteries, 25 veins.

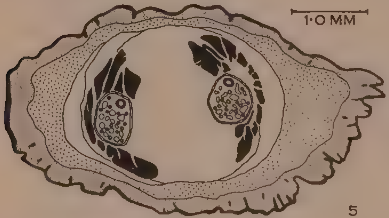
Macrotis lagotis Reid (rabbit-bandicoot) (Fig. 5).—Rete as in *P. gunni*. Fibrous sheath thick; cremasteric coat deficient medially, moderately thick elsewhere. 15 arteries, 14 veins.

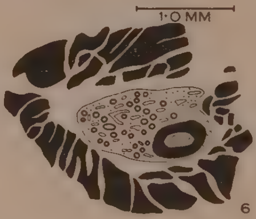
Macrotis minor Spencer (lesser rabbit-bandicoot).—Rete and coverings as in *P. gunni*. 8 arteries, 10 veins.

Chaeropus ecaudatus Ogilby (pig-footed bandicoot) (Fig. 6).—Only one cord examined. Well-defined rete. Thin fibrous sheath; cremasteric coat scanty medially, very thick elsewhere. 29 arteries, 21 veins.

Family Notoryctidae

Notoryctes typhlops Stirling (marsupial mole) (Fig. 7).—Single artery and vein. Thin fibrous sheath; cremaster represented by scattered muscle fibres only.





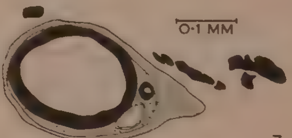


Fig. 5.— Spermatic cords of *Macrotis lagotis*, enclosed within tubular skin fold. Fine stippling: dermis. White area between cords occupied by fat.

Fig. 6.—Spermatic cord of *Chaeropus ecaudatus*. The right side of the figure adjoins the neighbouring cord.

Fig. 7.—Spermatic cord of *Notoryctes typhlops*.

Family Macropodidae

Thylogale billardierii Desmarest (rufous-bellied pademelon).—Very large, regular rete. Fibrous sheath thick, especially medially; cremasteric coat very thick laterally, thinner medially. 72 arteries, 98 veins.

Potorous tridactylus Kerr (potoroo) (Fig. 8).—Rete with few and widely spaced vessels. Fibrous sheath thin; cremasteric coat thick but diffuse. 6 arteries, 6 veins.

Caloprymnus campestris Gould (desert rat-kangaroo) (Fig. 9).—Large, regular rete. Thick fibrous sheath; moderately thick cremasteric coat. 46 arteries, 38 veins.

Other Species Examined by Harrison (1948, 1949, 1951)

Family Macropodidae

Macropus rufogrisea fruticus (Bennett's wallaby) (= *Wallabia rufogrisea frutica* Ogilby).—Rete present. 96 arteries.

Macropus eugenii (dama wallaby) (= *Thylogale eugenii* Desmarest).—Rete present. 154 arteries.

Macropus bicolor (black-tailed wallaby) (= *Wallabia bicolor* Desmarest).—Rete present. 118 arteries.

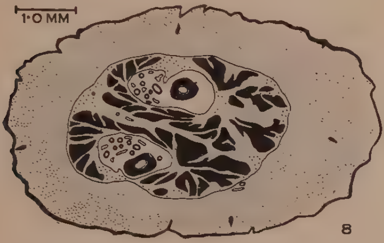
Macropus rufus (red kangaroo) (= *Megaleia rufa* Desmarest).—Rete present. Number of vessels not stated.

Family Vombatidae

Phascolomys mitchelli (common wombat) (= *Vombatus hirsutus* Perry).—Rete present. Number of vessels not stated.

Family Didelphyidae

Didelphis virginiana (Virginian opossum) (= *Didelphys marsupialis virginiana* Kerr).—Rete present. 50 arteries.



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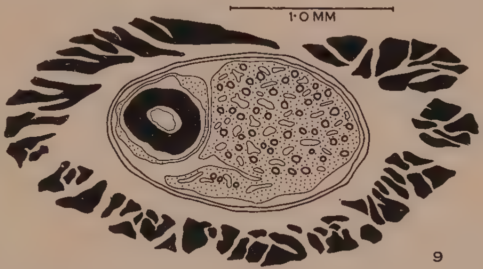

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Fig. 8.—Spermatic cords of *Potorous tridactylus*, enclosed within tubular skin fold. Fine stippling: thick dermis.
Fig. 9.—Spermatic cord of *Caloprymnus campestris*.

IV. DISCUSSION

Though not universally present, a testicular rete mirabile has been found in the great majority of the marsupials examined, and the authors suggest that the frequent occurrence of this remarkable vascular modification should be mentioned in any list of the diagnostic characters of the Metatheria. Absence of a rete has been noted only in *Sminthopsis crassicaudata*, *Notoryctes typhlops*, and *Acrobates pygmaeus*, though it is very inadequately represented in *Phascogale tapoatafa* and *Potorous tridactylus*. It appears that the rete is best developed in the larger members of each family.

There is some evidence that the regularity of the retial vessels is related to the taxonomic position of the species concerned. For example, the arteries and veins are very regularly intermingled in all members of the Peramelidae and Macropodidae that have been examined, even in small animals such as *Macrotis minor* and *Caloprymnus campestris*. Among the Phalangeridae, on the other hand, a regular rete with parallel unbranching veins and arteries of equal size is seen only in one species out of seven—*Trichosurus vulpecula*. Again, the coverings of the spermatic cord seem to vary somewhat among the different families. The cremasteric muscle coat is uniformly very thick in the Dasyuridae, for example, while in the Peramelidae it is very thin, or even deficient, on the medial aspect of each cord.

Harrison (1949) considered that the testicular rete of marsupials is a device for keeping the temperature of the testis below that of the abdominal cavity, in order to maintain effective spermatogenesis. The venous blood issuing from the testis is said to "pre-cool" the blood in the adjacent arteries of the rete. The fact that the rete is least developed in very small marsupials, the small testes of which would not require a cooling mechanism, and that it is absent in *Notoryctes typhlops* (in which the testes lie within the musculature of the abdominal wall) supports Harrison's hypothesis. On the other hand, no correlation has been observed between the degree of development of the rete and the body temperature of the species concerned, as given by Wislocki (1933). Moreover, the presence or absence of a rete seems to be unrelated to the normal temperature of the environment.

An interchange of heat between the arterial and venous streams must occur within a closely packed vascular bundle, as evidenced by the fact that such an interchange occurs, as an incidental feature, between the adjacent main arteries and veins of the human limbs (Bazett *et al.* 1948). Nevertheless, it is difficult to see why a more elaborate cooling device is required in the marsupial spermatic cord than in that of a eutherian mammal, or why the epididymis (in two species, at least) is also supplied by a rete. It may be that the marsupial rete performs some additional function. The close anatomical resemblance between this rete and the various retia mirabilia found in sloths, some slow moving primates, and many aquatic mammals (Wislocki and Straus 1932; Fawcett 1942) indicates that they may all have a similar physiological significance—perhaps they act as venous pumps as suggested by Müller (1904). Experiments upon living marsupials are required before it can be accepted that the testicular rete acts solely as a device for heat exchange.

V. ACKNOWLEDGMENTS

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SPECIATION IN THE GENUS *AMYTORNIS* STEJNEGER (PASSERES: MUSCICAPIDAE, MALURINAE) IN AUSTRALIA

By A. KEAST*

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Summary

The present paper discusses and determines the status of a range of forms and species in the genus *Amytornis* Stejneger (Australian grass-wrens), reviews infraspecific variation and re-defines races, and makes a study of speciation in the genus.

In demonstrating the various stages in the speciation process *Amytornis* provides a parallel with *Climacteris* Temminck (Keast 1957). The genus is particularly rich in distinctive isolated forms that, though they have never had their true status tested by contacting the parental stocks, are nevertheless so different that, if normal taxonomic procedure be applied, they must be regarded as species. There is one demonstration of the ultimate stage in the speciation process, that of two former isolates secondarily coming together and demonstrating their distinctness by failing to interbreed. *Amytornis* contrasts with *Climacteris* in that it is fundamentally a desert genus, with spinifex the basic habitat. Hence isolation of populations would appear to have resulted, in the main, not from increasing aridity, but as a result of the invasion of former spinifex or porcupine grass areas by savannah grassland (an unsuitable habitat as it provides cover for only part of the year).

Changes in the colour and colour pattern of the birds and in size and bill form (inferring a change in the food) of *Amytornis* provide, to a degree, a continental example of the kind of speciation seen in some island archipelagos, e.g. Galapagos Is. (Lack 1947).

The application of Gloger's and Bergmann's ecogeographical rules to members of the genus *Amytornis* is discussed.

I. INTRODUCTION

The genus *Amytornis* Stejneger (Australian grass-wrens), one of the few truly desert groups in the Australian avifauna, is a self-contained unit with relationships to other malurine genera such as *Dasyornis* and *Calamanthus*. These small "warbler-like" birds have all been placed in the Muscicapidae in the latest classification, that of Mayr and Amadon (1951). Their habit is wren-like, keeping to thickets near the ground, and their long tails are sometimes carried erect. The colouring is drab, brown colours being dominant, and the typical features are the longitudinal striations that give camouflage in the porcupine grass. They are sedentary with a marked tendency to occur in "pockets", though to the superficial viewer the habitat may appear to be continuous. All species are secretive, moving through the dense spinifex and undergrowth like rodents.

II. MATERIALS, METHODS, AND DEFINITIONS

The taxonomic section of this work was carried out on the bird collections of the American Museum of Natural History, New York (which includes the Mathews

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* Australian Museum, Sydney.

types) the Australian Museum, Sydney, the National Museum of Victoria, Melbourne, and the South Australian Museum, Adelaide.

The study of geographic variation has followed standard taxonomic methods. In most instances bill, wing, and tail measurements are given for *adult males* only. The wing, as has been shown by Amadon (1943), is fairly good criterion of overall size in birds.

The word "isolate", as used in this work, means a population that has been cut off from the main stock by a distributional barrier and that, in association with that isolation, has undergone morphological differentiation. In that isolation is the first step in the speciation process these forms can be said to have the "potential" of developing into new species. Few, of course, will ever reach that state. They are to be contrasted with clinal forms that, though visibly distinct, are still in distributional and reproductive contact with the parental stock.

Spinifex and porcupine grass, members of the genus *Trioda*, are alternative ecological areas for members of the genus *Amytornis*.

III. The Species and their Relationships

The genus *Amytornis* has long been confused taxonomically. This has simply stemmed, in part, from uncertainty as to the status of four distinctive, isolated forms, each known from only one locality and, in effect, a relict population. Recently Condon (1951) listed three of them as species (vide *goyderi*, *woodwardi*, *housei*), and the other as a race (*dorotheae*). However, even the last is quite distinctive and, though its actual genetic status must remain in doubt, it can best, for taxonomic purposes, be regarded as a species.

Amytornis falls into two species groups, the *striatus* group, which has a rich and somewhat complicated colour pattern, and the *textilis* group, with a simple colour pattern. Behavioural differences between typical species in the two groups include a "sweet, rippling song" in *A. striatus* and the absence of song in *A. textilis* (Whitlock 1924).

The apparent relationships of the species and races of *Amytornis* are set out in Figure 1. It will be seen that in the *textilis* group there is an early offshoot towards species with a heavy grain-eating type of bill (Fig. 2). Most aberrant is *A. goyderi*, a species not recorded since 1875. A chain of species leads from *A. striatus* proper through *A. dorotheae* and *A. woodwardi* to *A. housei* (Fig. 3). The changes involve an increase in size, marked modifications in colour pattern, and the development of an almost black form. The bill, however, remains substantially the same. *A. housei* has markings not unlike those of *A. textilis* and possibly should be associated with that species rather than *A. striatus*. Differences between the species groups of *Amytornis* are set out below.

(*a*) A. textilis *Group* (*Fig.* 2)

This group comprises plain birds, which are brown or reddish dorsally, pale ventrally, and with no colour pattern other than whitish longitudinal striations that are mainly on the dorsal surface.

A. textilis.—Generally brown above with reddish tinge (strongly developed in desert races) and with a long, narrow, insectivorous-type bill (average width/length ratio=0·50).

A. modestus.—Brown dorsally without reddish tinge, ventral markings reduced. Bill moderately heavy (average width/length ratio=0·63).

A. goyderi.—Rufous above, white below, pallid, ventral markings lost. Short, heavy bill, typical of a grain feeder (width/length ratio of single male=0·87).

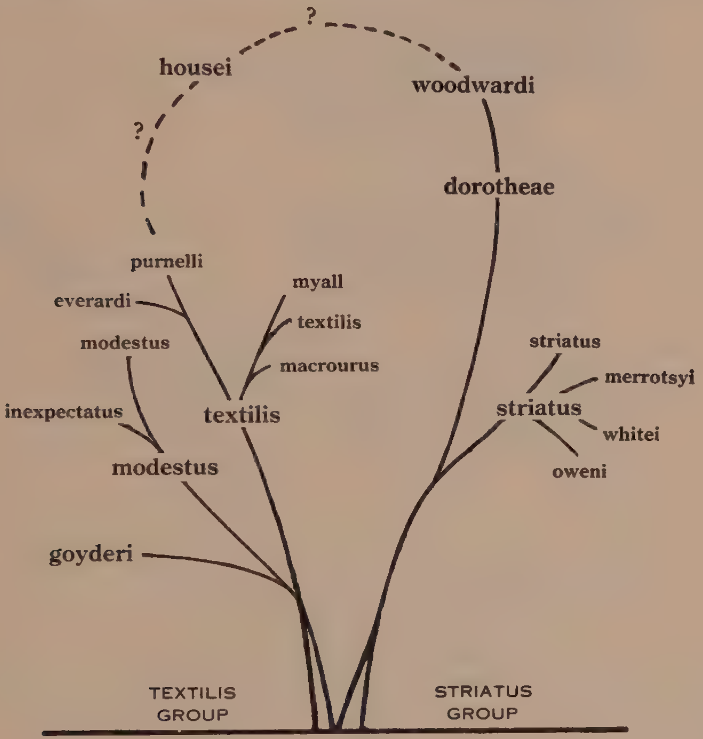

Fig. 1.—Relationships of species and races in the genus *Amytornis*. It is uncertain from which group *A. housei* is derived.

(*b*) A. striatus *Group* (*Fig.* 3)

In this group the colours are brighter, more contrasting, of greater range, and the pattern is more complicated. In all species the bill is long and narrow.

A. striatus.—Dorsal coloration chestnut or rufous, longitudinal striations white with black edgings. A rufous mark extends forwards over the eye and there is a black malar stripe. Throat pale, breast marked with blackish striations.

A. dorotheae.—Somewhat larger and heavier species. There is an increase in black anteriorly and dorsally and the white throat and breast are conspicuous. Sexual dimorphism would appear to be of the same degree as in the genus generally (Mathews 1923), i.e. the flanks of the females are rufous, those of the males plain.

A. woodwardi.—Large species. Dorsal surface and face heavily suffused with black, the back and tail to a somewhat lesser extent. The white of the throat and upper breast is as conspicuous as in *A. dorotheae* but a black line now separates it from the abdomen, which is coloured. A further new character is that the abdomen is different in the two sexes, brown in males and chestnut in females.

A. housei.—This species is the same size as *A. woodwardi* but black is now the dominant colour and patterning is restricted to the longitudinal whitish striations anteriorly. The female is unknown.

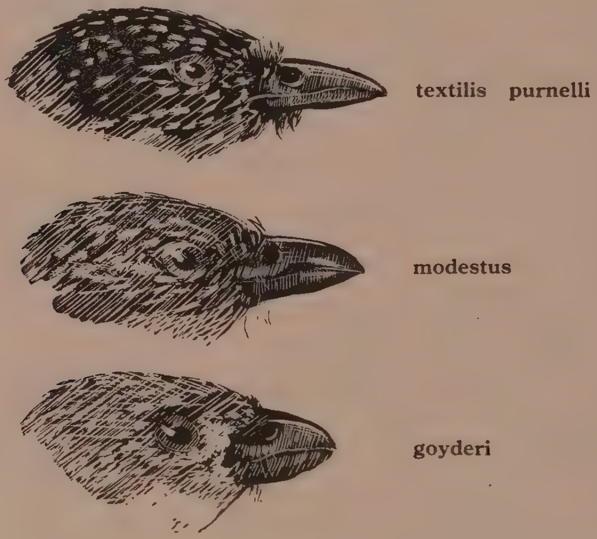

Fig. 2.—Heads of the three species of the *A. textilis* group showing stages in transition from the generalized "insectivorous" bill to the heavy bill of the seed eater. (J. Beeman del.)

Dimensions of some species and races of *Amytornis* are given in Table 1. Figures 4 and 5 show ranges, geographic variation in habitat, and distributional barriers. Coloured plates of the various species can be seen in Mathews (1923).

Evolutionary changes in size, bill form (inferring changes in diet), colour, and colour pattern, as seen in the genus *Amytornis*, are remarkably great for a closely related and compact group of species. In this and in the confinement of the more distinctive species to habitable pockets in isolated sections of the continent are examples of development similar to that of isolates on island archipelagos, e.g. the Galapagos Is. (Lack 1947).

IV. Taxonomy

(a) *Infraspecific Variation*

Amytornis textilis (Dumont)

(western grass-wren)

Malurus textilis Dumont, 1824, Dict. Sci. Nat. **30**: 117.

Distribution.—The southern half of the continent from the west coast to central Australia (Fig. 4) . The northern range limits would appear to be Point Cloates, W.A. (Serventy and Whittell 1951) and the Macdonnell Ranges, N.T., i.e. approximately along the line of the Tropic of Capricorn. (*Note*: the "sight" records of Keartland (1904) for the Margaret R. in the north-west of Western Australia and those of Jarman (see Condon 1951) for Barrow Creek in central Australia require confirmation.)

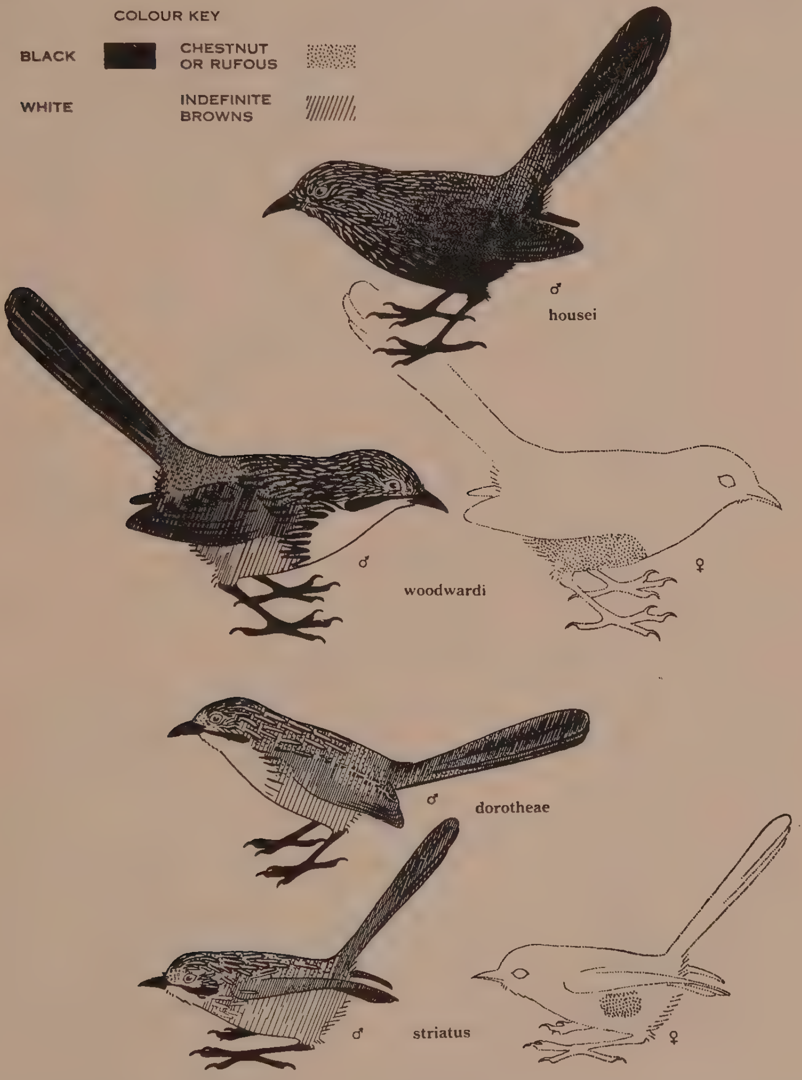

Fig. 3.—Species of the *A. striatus* group showing differences in colour and colour pattern. From *striatus* through *dorotheae* to *woodwardi* there is a natural progression in size and the acquisition of new characters. The overall pattern gradually changes, sexual dimorphism being pronounced in *woodwardi*. *A. housei*, an almost black species, could be a derivative of the *textilis*, not *striatus*, group. (B. Bertram del.)

Habitat.—Semi-arid country and desert. *A. textilis* is recorded by Carter as occurring in scrub and thickets on and near the west coast, in saltbush (E. Murchison) by Whitlock, and in the Gawler Ranges by White (see Mathews 1923), and also in

TABLE 1

DIMENSIONS OF SPECIES AND RACES OF ADULT MALES OF THE GENUS AMYTORNIS

In this and subsequent tables the bill length has been measured from the base of the terminal feathers to the tip, the bill width at the former, the wing from its angle to tip, straightened along a rule, the tail from between the base of the central-most feathers to the tip. Mean values are shown in parenthesis

Species or Race	Sample Size	Bill Length (mm)	Bill Width (mm)	Bill Width/Length Ratio	Wing Length (mm)	Tail Length (mm)	Tail Length/ Wing Length Ratio
*A. textilis textilis**	9	9·4–10·2 (9·8)	5·0–5·4	0·54–0·57	65–70 (66)	85– 93 (90)	1·26–1·40 (1·34)
A. modestus modestus†	4	8·7– 9·2 (9·0)	5·5–5·9	0·61–0·64	60–67 (63)	73– 78 (76)	1·08–1·18 (1·14)
A. goyderi	1	8·3	7·2	0·87	58	73	1·26
A. striatus striatus‡	18	8·6– 9·4 (9·0)	4·2–4·4	0·44–0·49	61–68 (64)	82– 91 (87)	1·30–1·42 (1·36)
A. dorotheae	5	9·8–10·2 (9·9)	4·8–5·0	0·47–0·48	65–68 (67)	86– 93 (89)	1·32–1·44 (1·36)
A. woodwardi	5	11·6–12·1 (11·8)	5·2–5·7	0·43–0·49	75–79 (76)	98–112 (104)	1·32–1·39 (1·36)
A. housei	1	11·6	5·5	0·47	80	93	1·16

*Specimens from Peron Peninsula and Dirk Hartog I., W.A.

†Specimens from the Macdonnell Ranges, N.T.

‡Specimens from the Eastern Mallee, S.A.

spinifex in the Great Sandy Desert by Keartland (1904). In central Australia, it is restricted to the rocky spinifex-covered surfaces of the mountains (Mathews 1923; Whitlock 1924; Campbell 1927; Jarman 1953; Fletcher, personal communication), the flat country being occupied by the closely related *A. modestus*. (It might be noted, as Whitlock (1924) has pointed out, that Keartland (1904) has transposed the habitats of *A. textilis* and *A. modestus* in his writings.) The populations of *A. textilis* in the Macdonnell, James, Everard, and Musgrave Ranges of central Australia are isolated from the western populations of the species. Variation in the habitat of *A. textilis* and its relation to *A. modestus* are shown in Figure 4.

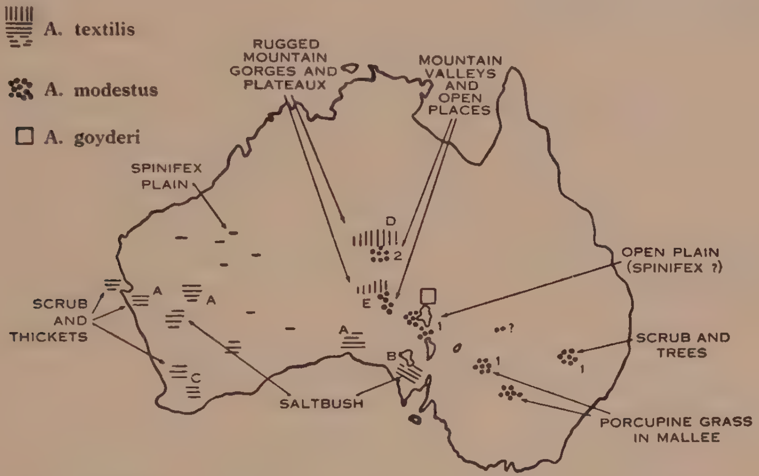

Fig. 4.—Distribution and habitat variation in species of the *textilis* group. In central Australia, where both *A. textilis* and *A. modestus* occur, each occupies a different habitat. *1*, *A. m. inexpectatus*; *2*, *A. m. modestus*; *A*, *A. t. textilis*; *B*. *A. t. myall*; *C*, *A. t. macrourus*; *D*, *A. t. purnelli*; *E*, *A. t. everardi*, subsp. nov.

Geographic variation.—Five races of *A. textilis* may be distinguished:

(i) *A. t. textilis* (Dumont), 1824. Coastal mid-western Australia to the Nullarbor Plain (Fig. 4, *A*), thence grading into the barely differentiated Gawler Range race (Fig. 4, *B*). Specimens from the extremities of the range, Peron Peninsula, W.A., and Ooldea–Tarcoola, S.A., are similar. Mathews (1923) and Campbell (1927) have laid stress on differences between the populations from Peron Peninsula and Dirk Hartog I. The author agrees that the latter birds do tend to be a little blacker on the average but the amount of individual variation precludes their being recognized as a race.

(ii) *A. t. myall* (Mathews), 1916. Gawler Ranges, S.A. (Fig. 4, *B*). The author agrees with Condon (1951) that this minor race is characterized by a whiter chin, distinct white striations on the throat and breast, and paler abdomen.

(iii) *A. t. macrourus* (Gould), 1847. Higher rainfall areas of the south-west corner of the continent. Typical specimens have been obtained from Broome Hill, Beverley, Wongan Hills, W.A. (Fig. 4, *C*). In this race the head is distinctly darker (the area of black on each feather being increased), and the abdomen is not cream-coloured but brownish, like the breast. The tail is distinctly longer (see Table 2). *A. t. macrourus* represents the end of a colour and size cline extending southwards from typical *t. textilis*. The transition is seen in specimens from Kalgoorlie which are slightly darker than typical *t. textilis* and are somewhat reddish underneath, whilst those from Day Dawn and Yalgoo, W.A., approach the darker colouring of typical *t. macrourus*.

(iv) *A. t. purnelli* (Mathews), 1914. Macdonnell and James Ranges, N.T. (Fig. 4, *D*). This race, long given species status, is strongly suffused with rufous, giving a darkened upper surface and a rich rufous breast.

TABLE 2

SIZE VARIATION IN ADULT MALES* OF AMYTORNIS TEXTILIS

Race	Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
A. t. textilis	Dirk Hartog I., W.A.	6	9·4–10·2 (9·8)	65–70 (66)	87– 93 (91)
A. t. textilis	Peron Peninsula, W.A.	6	9·4–10·2 (9·7)	63–69 (66)	85– 91 (87)
A. t. textilis	East Murchison, W.A.	4	9·1– 9·4 (9·3)	66–68 (66)	87– 90 (88)
A. t. macrourus	Broome Hill and Beverly, W.A.	6	9·5–10·0 (9·7)	65–72 (68)	91–100 (96)
A. t. myall	Gawler Ranges, S.A.	4	9·2– 9·8 (9·5)	63–66 (64)	82– 85 (84)
A. t. everardi	Everard Ranges, S.A.	4	10·5–10·8 (10·7)	62–65 (63)	78– 82 (80)
A. t. purnelli	Macdonnell and James Ranges, N.T.	6	9·7–10·4 (10·1)	60–64 (62)	75– 82 (77)

*Females tend to be slightly smaller than males in *Amytornis*. Comparative wing lengths of *A. t. purnelli* from central Australia are: males, 60–65 mm (mean of nine, 62 mm); females, 58–63 mm (mean of six, 61 mm).

(v) *A. t. everardi*, subsp. nov. Everard and Musgrave Ranges, S.A. (Fig. 4, *E*). This new race resembles *t. purnelli* in colour but has a distinctly long bill. Length of bills of three males range from 10·5 to 10·8 mm, and those of four females from 10·2 to 10·5 mm, whilst equivalent measurements for six male specimens of *t. purnelli* from the Macdonnell Ranges were 9·6–10·4 mm, and for two females 8·8 and 9·2 mm. The race is isolated. The type, a male, No. B1726 in the South Australian Museum, Adelaide, was collected by S.A. White in the Everard Ranges on August 12, 1914. A female, No. B1727, was collected on the same day.

Bill, wing, and tail length measurements of the various races of *A. textilis* are given in Table 2. Despite small samples the following size trends are indicated. Birds from central Australia have shorter wings and tails but have distinctly longer bills than those from elsewhere. The change in bill results from a lengthening, not an overall increase in bulk. The width of the bill of six males from the Macdonnell Ranges ranges from 5·1 to 5·4 mm, giving a width/length ratio of 0·49–0·55, compared with the range 5·0–5·4 mm and a width/length ratio of 0·54–0.57 for nine males from Peron Peninsula and Dirk Hartog I. Thus the distinctively coloured birds from central Australia also stand apart on size grounds.

The author's measurements confirm that the south-western race (*t. macrourus*) is characterized by a long tail, the tail length/wing length ratio of five males being 1·35–1·50, compared with 1·26–1·40 for nine males from Dirk Hartog I., 1·20–1·30 for six males from the Macdonnell Ranges, and 1·28–1·32 for four males from the Gawler Ranges.

The Gawler Range race (*t. myall*) would appear to be smaller in overall measurements than *t. textilis* and this has been suggested independently by Condon (1951). It certainly does not have the long tail of the south-western race nor the long bill of *t. purnelli*.

Variation in *A. textilis* would thus appear to be largely the result of isolation but it is also partly clinal, *t. macrourus* and *t. myall* probably representing the ends of clines.

Specimens seen.—WESTERN AUSTRALIA: Peron Peninsula (9); Dirk Hartog I. (10); East Murchison district (6); Yalgoo (2); Kalgoorlie (2); Broome Hill and Beverley (9). SOUTH AUSTRALIA: Ooldea (2); "142 miles west of Tarcoola" (1); Gawler Ranges (6); Everard Ranges (8). NORTHERN TERRITORY: Macdonnell and James Ranges (10). (Numbers in parenthesis represent size of sample of adult birds.)

AMYTORNIS MODESTUS (North)

(thick-billed grass-wren)

Amytis modesta North, 1902, Vict. Nat. **19**: 103.

Distribution.—Western New South Wales to central Australia, but decidedly "patchy" (Fig. 4), the species only having been recorded from the following localities: Lower Namoi R. (Gould 1865); Mossgiel, N.S.W. (see North 1904); Mt. Arrowsmith, north-western N.S.W. (type locality of the race *obscurior*); south and west of Lake Eyre (Condon 1951); Macdonnell Ranges. Mr. N. Favaloro has informed the author that an *Amytornis*, presumably this species, occurs in the extensive cane-grass "triangle" to the south of Bulloo Lake, south-western Qld. (Fig. 4, ?).

Habitat.—Plains studded with scrubs and low bush-like trees (e.g. Namoi R. (see Gould 1865)); cane grass, soft spinifex, and stony areas in the valleys of the mountains and on adjacent plains of central Australia (North 1904; Whitlock 1924).

Geographic variation.—Specimens fall into two series:

(i) *A. m. inexpectatus* (Mathews), 1912. Western New South Wales to Lake Eyre, S.A. (Fig. 4, *1*). In this form there are faint longitudinal markings on the throat and upper breast (absent in *m. modestus*) and the faint rufous tinge through the back and under parts is lacking.

(ii) *A. m. modestus* (North), 1902. Macdonnell Ranges, N.T., and, apparently, the Musgrave Ranges, S.A. (Mathews 1923) (see Fig. 4, *2*).

Measurements of adult males of *A. modestus* are given in Table 3. The bill width/length ratios of specimens of *m. modestus* from the Macdonnell Ranges range from 0·61 to 0·64, and for the New South Wales specimens of *m. inexpectatus* 0·60–0·63. Tail length/wing length ratios are 1·08–1·18 and 1·21–1·26 respectively. The number of birds in these series is too small to determine if geographic size variation exists. It is not suggested by these values.

Thus, variation in *A. modestus* is apparently minor. Ecological evidence indicates several range gaps in the east and there is possibly an extensive one between Lake Eyre and the Macdonnell Ranges.

Specimens seen.—NEW SOUTH WALES: Namoi R. (2); Mossgiel (3); Mt. Arrowsmith (1). SOUTH AUSTRALIA: Lake Eyre and Oodnadatta (5). NORTHERN TERRITORY: Macdonnell Ranges (8).

TABLE 3

SIZE VARIATION IN ADULT MALES OF AMYTORNIS MODESTUS

Race	Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
A. m. inexpectatus	Mossgiel and Mt. Arrowsmith, N.S.W.	4	8·8–9·2 (9·0)	60–65 (62)	76–82 (79)
A. m. inexpectatus	Lake Eyre–Oodnadatta, S.A.	3	8·9–9·2 (9·0)	61–64 (62)	72, other tails broken
A. m. modestus	Macdonnell Ranges, N.T.	4	8·7–9·2 (9·0)	60–67 (63)	73–78 (76)

AMYTORNIS GOYDERI (Gould)
(eyrean grass-wren)

Amytis goyderi Gould, 1875, Ann. Mag. Nat. Hist. (4)**16**: 286.

Distribution.—Lower Macumba R., immediately to the north of Lake Eyre (Fig. 4).

Habitat.—Not stated, but the journal of the expedition on which the only known specimens were taken (see extracts by Sutton 1927) describes the Lower Macumba R. area as being covered with flats of prickly *Acacia*, spinifex, and samphire in between barren sandhills and claypans. The area has an annual rainfall of less than 5 in.

Geographic variation.—This species is known only from the type locality. Of six specimens obtained by F. W. Andrews in 1875 only three are now known to exist, two in the British Museum (Natural History) and one in the Australian Museum, Sydney (Hindwood 1945). The measurements of the single male seen by the author are given in Table 1.

AMYTORNIS STRIATUS (Gould)
(striated grass-wren)

Dasyornis striatus Gould, 1840, Proc. Zool. Soc. Lond. **1839**: 143.

Distribution.—Lower Namoi R., western N.S.W., to the Victorian Mallee, thence to Eyre Peninsula, S.A., (Condon 1951), Leigh Creek, S.A. (Terrill and Rix 1950), Musgrave Ranges, S.A. (McGilp 1935), "almost throughout central Australia wherever the porcupine grass abounds" (North and Keartland 1896), and north to lat. 19, near Tanami, N.T. (Hill 1913). The range in Western Australia is from the East Murchison district to Godfrey's Tank (Serventy and Whittell 1951) (see Fig. 5).

Although it would appear from the above that the range is continuous, specimens fall into two series: (i) those from New South Wales–SE. South Australia, and (ii) those from central–Western Australia. Only two or three specimens have been collected from central Australia, despite reasonably widespread collecting (cf. good collections of *A. textilis* and *A. modestus* from this area). This is evidence of an extensive range gap between the distinctive eastern and western forms of *A. striatus*.

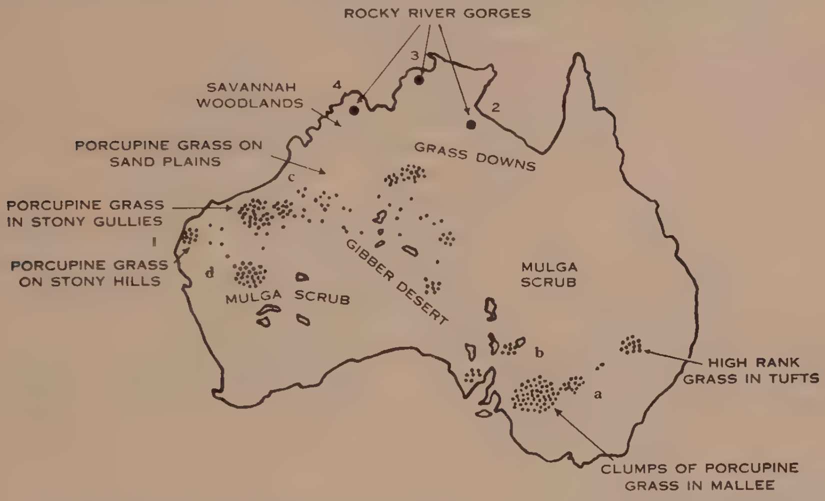
ROCKY RIVER GORGES
3
4
SAVANNAH WOODLANDS
2
PORCUPINE GRASS ON SAND PLAINS
GRASS DOWNS
c
PORCUPINE GRASS IN STONY GULLIES
1
GIBBER DESERT
PORCUPINE GRASS ON STONY HILLS
d
MULGA SCRUB
MULGA SCRUB
b
HIGH RANK GRASS IN TUFTS
a
CLUMPS OF PORCUPINE GRASS IN MALLEE

Fig. 5.—Distribution of species and races of the *striatus* group. *1, A. striatus*; *a, A. s. striatus*; *b, A. s. merrotsyi*; *c, A. s. whitei*; *d, A. s. oweni*; *2, A. dorotheae*; *3, A. woodwardi*; *4, A. housei.*

Habitat.—Porcupine grass or spinifex of flat, desert plain and mallee areas is present over the bulk of the range. At the eastern extremity (Namoi R.) it is said to have inhabited high rank grass growing in tufts (Gould 1865) and at the western end spinifex in stony gullies (Pilbarra, W.A.) and spinifex on stony hills (North West Cape) (see Mathews 1923). Thus the species occupies rocky areas where these are not occupied by another member of the genus. The range, habitats, and distributional barriers of *A. striatus* are set out in Figure 5. A feature of the species is its "extreme local tendencies" (see Mathews 1923). Its sedentary habits, plus known discontinuities in the habitat, favour the isolation of populations.

Geographic variation.—Distinctive colour types occupy the south-east and central–north-west areas of the continent respectively.

(i) *A. s. striatus* (Gould), 1840. Western New South Wales to southern South Australia (Fig. 5, *a*). This race has a rich and diverse colouring, the range embracing chestnut, black, white, and various brown tones. There is no difference in specimens from New South Wales, the Victorian Mallee, and south-eastern South Australia, notwithstanding the remarks of Campbell (1927).

(ii) *A. s. whitei* Mathews, 1910. North West Cape–Fortescue R.–Nullagine section of Western Australia (Fig. 5, *c*). This form is characterized by a reduction in the black areas on the dorsal feathers and a brightening and lightening of the chestnut areas, so that the back is now uniformly bright rufous in colouring. This race has a long bill (Table 4). There is a minor colour variation, especially at the southern end of the range, which form, on account of its shorter bill, must be granted race status (*s. oweni*).

(iii) *A. s. oweni* Mathews, 1911. East Murchison district, W.A., extending eastwards (apparently) to central Australia (Fig. 5, *d*). East Murchison specimens are redder on the back than *s. whitei* and the longitudinal black markings on the feathers are absent. There is a gingery suffusion over the breast and abdomen. The single specimen seen by the author from central Australia (a female from Mt. Kintore in the Musgrave Ranges) is of this type. The specimens collected by Hill on the Calder R. near Tanami and said to have a richly toned upper surface, light abdomen, and faint ventral striations (Campbell 1927) have not been seen by the author, so that the allocation of this population also must remain in some doubt. It was originally described as a separate race (*rufa* Campbell & Kershaw, 1913) but this was later reduced to synonymy (Mathews 1923).

TABLE 4

SIZE VARIATION IN ADULT MALES OF AMYTORNIS STRIATUS

Race	Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
A. s. striatus	Byrock, Mossgiel, N.S.W.	4	8·8– 9·2 (9·0)	62–66 (63)	84–88 (86)
A. s. striatus	Victorian Mallee	10	8·7– 9·4 (9·1)	62–66 (64)	82–89 (87)
A. s. striatus	Eastern Mallee, S.A.	10	8·6– 9·4 (9·0)	61–68 (64)	84–91 (88)
A. s. oweni	East Murchison R., W.A.	6	9·3–10·1 (9·8)	57–61 (59)	77–83 (80)
A. s. whitei	Hammersly area, W.A.	6	10·7–11·5 (11·1)	62–65 (64)	85–88 (86)

One other geographic form of *A. striatus* has been described, *merrotsyi* Mellor, 1913, the type specimen (now missing) coming from Yudanamutana in the Flinders Ranges, S.A. (Condon 1951)—see Figure 5, *b*. It possibly represents a population intermediate between *s. striatus* and *s. whitei* for it is described as being light rufous or chestnut on the head and mantle and as having a less prominent malar stripe than the former. Coloured plate No. 469 of Mathews (1923), however, suggests that it is no paler dorsally than *s. striatus*.

Measurements of series of adult males of *A. striatus* from different parts of the range are given in Table 4. These measurements are chiefly of significance in disclosing the markedly longer bill of specimens from the north-western part of the range (*s. whitei*). Six males of this race have bills ranging in width from 4·5 to 4·7 mm, and have a width/length ratio of 0·39–0·41, compared with 4·2–4·4 mm and 0·44–

0·49 for 18 males of *s. striatus* from the Victorian Mallee and the Eastern Mallee, S.A. The tail length/wing length ratios of the two groups are little different: 1·28–1·35 as against 1·30–1·42. The East Murchison population would appear to be the smallest in wing and tail length (Table 4.). No male specimens were available for measurement from central Australia. The female from Mt. Kintore, however, has a wing length of 59 mm, compared with 60–65 mm for females from the Victorian Mallee (mean of eight, 63 mm).

Thus, *A. striatus* is broken up into two distinctive colour groups, each being relatively uniform over an extensive area and probably isolated, especially the north-western long-billed race (*s. whitei*).

Specimens seen.—NEW SOUTH WALES: Lower Namoi R. (2); Byrock and Mossgiel (4). VICTORIA: North-western Mallee (19). SOUTH AUSTRALIA: South-eastern corner—Pinnaroo, Chapman's Bore, Peebinga, Karoonga (18); Mt. Kintore, Musgrave Ranges (1, female). WESTERN AUSTRALIA: Fortescue R. (2); Nullagine (3); Hammersley Ranges (1); Coongan R. (2); North West Cape (2); East Murchison R. (10).

AMYTORNIS DOROTHEAE (Mathews)
(dorothy grass-wren)

Magnamytis woodwardi dorotheae Mathews, 1914, Aust. Av. Rec. **2**: 99.

Distribution.—Recorded only from the McArthur R., N.T. (Fig. 5, *2*).

Habitat.—Spinifex on broken sandstone plateaux never venturing far from the rocky areas (Barnard 1914).

Geographic variation.—Nil. *A. dorotheae* occupies a position, both morphologically (see Fig. 3) and distributionally, between *A. striatus* and *A. woodwardi*. If anything it is more closely related to the former. *A. dorotheae* is a form that, though quite isolated, has reached such a stage of morphological distinctness that it can best be regarded, for taxonomic purposes, as a species. Measurements of five males of *A. dorotheae* are given in Table 1.

Specimens seen.—QUEENSLAND: McArthur R. (11).

AMYTORNIS WOODWARDI Hartert
(white-throated grass-wren)

Amytornis woodwardi Hartert, 1905, Bull. Brit. Orn. Club. **16**: 30.

Distribution.—*A. woodwardi*, an enlarged tropical derivative of *A. striatus* (see Fig. 3), was originally recorded from the S. Alligator R., N.T., in 1903. A female specimen was obtained from that area in 1948 by H. G. Deignan (personal communication). The species also occurs on the Mary R., N.T.

Habitat.—Rocky outcrops in river gorges (Fig. 5, *3*).

Geographic variation.—Nil.

Specimens seen.—NORTHERN TERRITORY: Alligator R. (10).

AMYTORNIS HOUSEI (Milligan)
(black grass-wren)

Amytis housei Milligan, 1902, West. Aust. Parl. Pap. No. 2. p. 52.

Distribution.—Charnley R., W. A., in the north-west Kimberleys (Fig. 5, *4*). Only three specimens of this distinctive species have been collected.

Habitat.—Rough country strewn with sandstone masses, over which it runs rapidly. House (1902) stresses that the distribution seems to be entirely determined by the colour of the rocks, the species having only been observed in sandstone areas in which the colour (red to black) harmonizes with its own.

Geographic variation.—Nil.

The relationships of *A. housei* will be better understood when more specimens are collected, especially females. It would be interesting to know if the two birds illustrated by Mathews (1923, Plate 474) are, in actual fact, both males as one of them has a light-coloured abdomen, a sex character of *A. woodwardi*. The large size of this species can be seen from Table 1.

Specimens seen.—WESTERN AUSTRALIA: Charnley R. (2)

(*b*) *Nomenclature and New Synonymy*

Amytornis textilis textilis (Dumont), 1824. Synonym: *carteri*.
Amytornis textilis macrourus (Gould), 1847. Synonyms: *varius*, *mortoni*.
Amytornis textilis myall (Mathews), 1916.
Amytornis textilis purnelli (Mathews), 1914.
Amytornis textilis everardi, subsp. nov.
Amytornis modestus modestus (North), 1902.
Amytornis modestus inexpectatus (Mathews), 1912. Synonym: *obscurior*.
Amytornis goyderi (Gould), 1875.
Amytornis striatus striatus (Gould), 1840. Synonym: *howei*.
Amytornis striatus merrotsyi Mellor, 1913 (subject to confirmation).
Amytornis striatus oweni Mathews, 1911.
Amytornis striatus whitei Mathews, 1910.
Amytornis dorotheae (Mathews), 1914.
Amytornis woodwardi Hartert, 1905.
Amytornis housei (Milligan), 1902.

V. SPECIES FORMATION

(*a*) *Forms with the Potential of Developing into New Species*

Within the genus *Amytornis* there is a range of forms representing different stages in the speciation process (cf. Keast 1957). The initial stages are represented by several barely differentiated (colour) populations which, because of the marked tendency of the species to occur in "pockets" and their general sedentariness, are presumably isolates. Present material does not, however, permit a proper delineation of these forms. They are scattered over the desert where suitable conditions occur and there they are "exposed" to climatic changes (which will either exterminate them or reunite them with the main stocks).

A subsequent stage in the process of speciation is seen in the well-differentiated forms of *A. textilis* (*t. purnelli* and *t. everardi*) in the mountains of central Australia. These are isolated by tracts of desert and are strongly favoured by their protective mountain habitat, to all intents and purposes a "permanent" one. Thus they have an excellent chance of reaching specific distinctness in a reasonably short time. Probably with an equally good evolutionary future but contrasting in that they are widely distributed and have a number of locally adapted populations are the reddish central and western isolates of *A. striatus* (*s. whitei* and *s. oweni*).

The existence of the isolated forms *A. dorotheae*, *A. woodwardi*, and *A. housei*, so divergent that they can only be looked upon as having reached species status (see Fig. 3) is one of the most interesting features of the genus *Amytornis*. Such a situation is without parallel in Australian birds, though many similar cases are to be expected in lower animal forms with poor dispersive capacities. In that they have never had the opportunity of breeding with the parental stock (*A. striatus* admirably fits the requirements of the parental species), nor each other, none of these can be regarded as proven genetic species. Any doubt as to the justification for regarding them as species, however, is assuaged by the fact that *A. textilis* and *A. modestus*, forms that have not reached such a stage of morphological differentiation, are good genetic species. These latter, meeting in central Australia and avoiding "competition" by occupying adjacent habitats, represent a fine demonstration of the end-point in the speciation process.

Thus, it is seen that the genus *Amytornis* contains examples of the full range of intermediate stages in the speciation process: minor isolate, moderately–well-differentiated isolate, distinctive isolate, and an isolate that, by secondarily meeting a parental species without interbreeding, has demonstrated that it has attained specific distinctness.

(*b*) *Geographic Variation in Habitat Occupied*

Since closely related species of Australian birds differ markedly in the type of habitat occupied, habitat must be regarded as virtually as important a species character as morphology (see Keast 1955). Hence it is important, in any speciation study, to try to understand how ecological differences between species have been built up. Habitat is important in another way for, since the various vegetation associations differ in the degree to which they are "broken up", the chances of isolates developing vary with, amongst other things, the habitat occupied.

The species of *Amytornis* provide an excellent demonstration of how differences in the habitat occupied may be built up coincidental with the acquisition of morphological differences. This can be seen from Figures 4 and 5, the habitat occupied in each area being detailed on the maps. In the case of the *A. textilis* group (Fig. 4), each of the species *A. textilis* and *A. modestus* is somewhat diverse in choice of habitat within its own realm, but in central Australia, where they coexist, each choses a mutually exclusive "special" habitat. Such a situation in zoology is generally ascribed to the circumstances of interspecific competition, it being presumed that the one was already in occupation of the "choice" habitat when the second one entered the area, forcing it to accept an alternative habitat, to which it was already somewhat adapted. Subsequently, each tends to keep to the habitat where it is at an advantage and does not have to compete with the other. Such postulations would certainly seem to apply to *A. textilis* and *A. modestus*.

Within the widely ranging *A. striatus* (Fig. 5), habitats from high rank grass to spinifex on sandy plains and spinifex on stony hills and in stony gullies are occupied. The species *dorotheae*, *woodwardi*, and *housei*, in the north of the continent, live amongst broken rock in river gorges. Though in each case they are presumably the *only available* habitat, the bird species can be regarded as having been "preadapted" to them by the ecological versatility of the parental *A. striatus*. *A. striatus*, for its part, could be said to have populations differentiating in habitat just as they are differentiating morphologically.

(*c*) *Isolation and its Development*

The species of *Amytornis* keep low down in the spiny porcupine grass or amongst the rocks and boulders, have weak wings, prefer running to flying, and never rise above the ground (so that the chances of individuals being caught up by a gale are negligible). Accordingly, the dispersive capacities of *Amytornis* must be regarded as very poor and much isolation of populations is to be expected. This is exactly what we find.

The distribution map of the *striatus* group (Fig. 5) indicates the physical and vegetational features that must be impenetrable barriers to the dispersion of members of the group which have great need of surface cover. Salt lakes, gibber desert, and mulga scrub (see vegetation map of Prescott 1931) break up its distribution. The three northern species (*dorotheae*, *woodwardi*, and *housei*), by contrast, are isolated from each other and from *striatus* by savannah grass downs, which, in contrast with spinifex-covered areas, do not provide the necessary cover throughout the year. The dominant grasses on the downs, the so-called Mitchell (*Astrebla* spp.) and Flinders (*Iseilema* spp.) grasses, lush during and after monsoonal rains, virtually die away in dry seasons and during droughts. Such country is obviously quite unsuitable to *Amytornis*. Accordingly, there would appear to be a gap some 300 miles wide between the northernmost *striatus* (in the region of lat. 19) and *dorotheae*. And to the north and west of *dorotheae*, 300 and 700 miles distant respectively, *woodwardi* and *housei* are likewise isolated by the absence of the necessary intervening cover.

The distribution and isolation of the forms and species in *Amytornis* can only be explained in terms of past climatic changes that have led to changes in the distribution of the basic spinifex habitat. Most interesting of these postulated changes are those necessary to explain the origin of *dorotheae*, *woodwardi*, and *housei*, species that have been peripherally "budded off" from *striatus* (the last-named possibly came from *textilis*), for these must have reached their present position at a time when spinifex extended through to the north coast. Marked climatic oscillations are known to have occurred in Australia during and since the Pleistocene (Browne 1945), particularly in the northward and southward movement of the desert belt. Various geographers, on theoretical considerations, admit that the north was formerly arid (Mayr 1944; Gentilli 1949). In postulating an explanation for the origin of *dorotheae* and *woodwardi*, the intermediate position of the former, both morphologically and distributionally, should be noted. Rainfall maps show that a tongue of dry country extends from the interior to the Gulf of Carpentaria, i.e. along an almost direct line between the ranges of *striatus* and *dorotheae*. Accordingly, it is to be expected that, in the event of a generalized deterioration in the climate of the north of the continent, it would be along this corridor that the desert spinifex would first reach the coast—and that, with an overall improvement in climate, it would be the last contact of the desert with the northern seaboard. This explains the closer relationship of *striatus* to *dorotheae* than to the other northern species.

Speciation in the *textilis* group would appear to have been initiated by the ancestors of *modestus* becoming isolated in the east of the continent from the western *textilis*. The barriers could, theoretically, have been arid ones (salt lakes, gibber desert, and the arid Simpson Desert) or, alternatively vegetation of an unsuitable type resulting from an improved continental climate. The former is certainly the more likely possibility. At any event, *modestus* has secondarily been able to pierce the barrier, apparently by working round the south of Lake Eyre, and reach central Australia.

A. goyderi, restricted to a small habitable pocket to the north of Lake Eyre represents the end-point of a trend (cf. bill length) visible in *modestus* and obviously had a common ancestor with that species. It is today hemmed in by the arid Arunta Desert to the east and north, Lake Eyre to the south, and by gibber plains to the west, all regions deficient or lacking in ground cover. As these are particularly effective barriers it is likely that they have never been populated and that the ancestors of *A. goyderi* reached their present position by moving around the foreshores of Lake Eyre presumably from the east or south.

(*d*) *The Influence of Physical Environment on Coloration and Size*

(i) *Species.*—Reddish coloration, loss of blackish eumelanins, paleness, and a reduction in markings, are pronounced in *goyderi*, the only species confined to arid desert (colour of sand, reddish). The average annual rainfall of its habitat is less than 5 in. per annum, the average temperature for the coldest month (July) is 50–55°F, and for summer (January) 80–85°F. *A. goyderi* is also the smallest species in the genus and is unique in having developed a thick bill of the grain-crushing type.

An increase in the amount of black, or dominance of black, is manifest in the isolated *dorotheae*, *woodwardi*, and *housei*, species living at the northern fringe of the range of the genus where the rainfall is fairly high, averaging 25–30, 50–60, and 30–40 in. per annum respectively. July temperatures average 70–80°F and those of January 80–85°F. As all rain falls in the hottest months the climate is actually a fairly dry one. The three species inhabit restricted areas of broken, dark-coloured rock in river gorges where, presumably, there is also a certain amount of shadow. As will be seen from the wing length measurements (Table 1) *dorotheae*, *woodwardi*, and *housei* are distinctly larger than the plain-dwelling species to the south. They have, however, retained the generalized type of bill (Fig. 3).

The three widely distributed species of the genus *Amytornis* (*textilis*, *striatus*, and *modestus*) inhabit a range of climatic areas. Populations of the first two, inhabiting desert areas, are distinctly reddish but the trend is barely discernible in *modestus*, possibly additional evidence of its recent arrival in central Australia. Both *textilis* and *striatus* vary geographically in size.

(ii) *Races.*—The reddish desert populations of *striatus* (*whitei* and *oweni*) and *textilis* (*purnelli* and *everardi*) inhabit areas where the average annual rainfall is 8–12 in., the winter (July) temperature averages 50–65°F, and January temperature

80–90°F. The habitat is spinifex, either on red sand or stony hills and plateaux where the rocks are reddish in colour.

The areas inhabited by the most darkly pigmented races (increase in black and brown tones) of *textilis* (*macrourus*) and *striatus* (*striatus*) have an average annual rainfall of 10–20 in., July temperatures averaging less than 50°F, and January temperatures of from 70 to 80° F. The colour of the substratum, whilst variable, is for the most part distinctly darker than the desert sands and the vegetational cover is presumably more complete.

It will be seen that there is a correlation between body coloration and rainfall in *Amytornis*, both at the species and the race level, but apparently not with environmental temperatures.

Geographic size trends within *textilis* and *striatus* cannot be finally resolved from the limited material available. There is, however, no apparent size difference (using wing length as the criterion) between those populations of *striatus* inhabiting the northern (warmer) and southern (colder) parts of the range, as would be expected. This apparently also applies to *textilis*, though here the southernmost form (*macrourus*) has a distinctly long tail. In the latter species the trend would appear rather to be in the direction of the isolated desert forms being smaller than those inhabiting the peripheral regions (west coast, south-west coast).

(iii) *Gloger's and Bergmann's Ecogeographical Rules.*—Reddishness in desert animals is a generalized phenomenon (see Buxton 1923; Cott 1940). It is to be seen in several Australian bird genera (*Calamanthus*, *Stipiturus*) and in many other vertebrates, as well as in numerous invertebrates. The occurrence of black species of *Amytornis* in dark rocky areas would appear, to a degree, to duplicate the situation in other parts of the world where populations inhabiting areas of dark-coloured (laval) rock are dark in colour, e.g. some American mammals (Benson 1933) and some Mesopotamian lizards (Parker 1935).

It is not proposed, in the present contribution, to enter into the controversy as to the relative importance of physical considerations, as against camouflage, in determining the coloration of desert animals. Gloger's ecogeographical rule (i.e. animal populations inhabiting dry regions are paler than those inhabiting areas of higher rainfall), generally considered to be associated with the advantages of a refractory surface in a hot climate, has the widest application in Australian birds. Thus, with their reddish colouring against red sand and body striations mimicking the sheaths of the porcupine grass, the desert *Amytornis* are most difficult to see. The splendid camouflage provided by the black colouring of the river-gorge species (cf. remarks of House 1902) has already been noted. Accordingly, both physical and camouflage considerations presumably influence coloration in *Amytornis*.

The body size in bird populations inhabiting the warmer regions of a continent is typically smaller than those living in colder areas. Such north–south clines, examples of Bergmann's ecogeographical rule (the physiological basis of which is presumed to be that larger bodies are more effective in heat conservation) are to be found in many Australian bird species and would be expected to occur in *Amytornis*. It applies to races generally but only sometimes to species for these can be regarded as having entered a new ecological niche with selection now operating in different directions (Mayr 1956).

The fact that infraspecific size variation in *A. textilis* is apparently not from south to north but between eastern (desert) and western (coastal) populations is potentially significant. Isolation is pronounced and, as also suggested by change in bill form and habitat, different selective pressures to those in continuously ranging species may be operative.

Apart from *A. goyderi*, the desert species of several bird genera are smaller than those inhabiting fertile regions (e.g *Stipituris ruficeps*, *Calamanthus campestris*), although this is by no means the rule. In certain cases small body size might be of value in the desert. The fact that *A. goyderi* has developed such a different bill (that of a typical seed eater) is additional evidence that a different set of characters are being selected for in the case of certain *Amytornis*.

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THE RELATIONSHIP BETWEEN SEASONAL MOVEMENTS AND THE DEVELOPMENT OF GEOGRAPHIC VARIATION IN THE AUSTRALIAN CHATS (*EPTHIANURA* GOULD AND *ASHBYIA* NORTH (PASSERES: MUSCICAPIDAE, MALURINAE))

By A. Keast*

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Summary

The present paper reviews the taxonomy of the Australian chats (*Epthianura* Gould and *Ashbyia* North) and demonstrates the close link between the occurrence of geographic variation in a species and aspects of its ecology, in particular the occurrence and extent of seasonal movements. The various species differ as follows:

E. crocea.—No seasonal movements, habitat specialized, distribution peripheral, and isolated in four widely separated river valleys. Marked geographic variation.

A. lovensis.—Negligible seasonal movements, habitat specialized, range continuous but very restricted. No geographic variation.

E. albifrons.—Somewhat nomadic over much of range, habitat generalized, distribution peripheral and inland. Isolated insular population (Tasmania) is the only one to have differentiated.

E. aurifrons.—Seasonal movements moderate but varying with area and nature of season, habitat fairly generalized, wide and continuous interior distribution. No geographic variation.

E. tricolor.—Markedly nomadic, and with seasonal shift in abundance from the south to the north of the continent. The habitat is generalized and the range interior and continuous. Breeding habits must tend to further accelerate gene flow. No geographic variation.

The ultimate influence of ecology on variation in the Australian chats is best seen from a comparison of the two "extreme" species, *E. crocea* and *E. tricolor*. In the former, a series of traits combine to produce a number of distinctive isolates, forms with the "potential" of developing into new species. In the latter, by contrast, the whole behavioural pattern is such as to make the development and maintenance of any geographic variation virtually impossible.

I. Introduction

Australian bird species vary greatly in the degree to which seasonal movements are developed, and in the nature of those movements (Keast 1956). The mildness of the continental climate is such that north–south movements of the " classic " type, the objective of which is to escape extreme cold, are little developed, and in the east, south, and north, where conditions are reasonably fertile throughout the year, a high proportion of species are " sedentary ", i.e. they remain in the same district throughout the year. On the other hand, in the interior the unpredictability of rainfall, periodic droughts, and the tendency for one section of the country to be

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*Australian Museum, Sydney.

well-watered one year and another the following one has led to the development of nomadism to a unique degree. This nomadism is random in that the extent and direction of movements varies from year to year. There is a distinct tendency on the part of a number of species, moreover, to move towards the north of the continent at the end of summer to exploit the good conditions initiated by the monsoon. The amplitude of seasonal nomadism in Australian birds varies with the species, being considerable in some, quite limited in others.

Table 1

SIZE VARIATION IN ADULT MALES AND FEMALES OF EPTHIANURA ALBIFRONS

In this and subsequent tables the bill has been measured from the base of terminal feathers to the tip, the wing from its angle to tip, straightened along a rule, the tail from between the base of the central-most feathers to the tip. Mean values are shown in parenthesis in this table and in subsequent tables also

Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
Adult males				
Emu Vale, Qld.	2	9·2, 9·7	70, 71	39, 40
Sydney area	14	9·2– 9·6 (9·4)	69–74 (71)	38–41 (40)
Inland New South Wales	10	9·2– 9·7 (9·5)	70–74 (72)	38–42 (41)
Melbourne area	10	9·0– 9·6 (9·4)	69–73 (72)	37–41 (39)
Victorian Mallee	8	9·2– 9·7 (9·5)	70–73 (72)	37–40 (39)
Launceston, Tas.	8	9·7–10·3 (10·1)	70–73 (71)	39–42 (41)
Port Lincoln, S.A.	2	9·3, 9·5	71, 74	39, 40
Albany and Wilson's Inlet, W.A.	8	9·1– 9·7 (9·4)	71–74 (73)	38–41 (39)
Point Cloates, W.A.	2	9·0, 9·5	69, 72	36, 39
Adult females				
Sydney	10	9·3– 9·6 (9·4)	68–72 (70)	37–41 (39)
Melbourne	7	9·4– 9·7 (9·6)	69–72 (71)	39–41 (40)
Launceston	7	9·8–10·5 (10·1)	70–72 (71)	36–40 (39)

The insectivorous chats (*Epthianura* Gould and *Ashbyia* North), of which there are five species, were chosen as the subject for the study as they constitute a self-contained group, and differ in the extent and type of seasonal movements and in patterns of distribution, habitat, and degree of adaptation to arid conditions.

The work has required a prior taxonomic analysis as geographic variation has been inadequately studied and nomenclature is complicated by the acceptance of several fallacious races.

II. Materials and Methods

The taxonomic section of this work was carried out on the bird collections of the American Museum of Natural History, New York (which includes the Mathews types), U.S. National Museum, Washington, Australian Museum, Sydney, National Museum of Victoria, Melbourne, and Western Australian Museum, Perth.

Standard taxonomic methods have been followed in the study of geographic variation. Methods of measurement of appendages are described in Table 1. Unless there is reason for doing otherwise, for the sake of brevity comparative measurements are given for adult males only. The wing, as has been shown by Amadon (1943), is a fairly good criterion of overall size in birds. Slightly more than half the specimens examined were males. *E. crocea* and *A. lovensis* are relatively rare species and available museum material is limited.

Relevant aspects of the ecology of the different species has been obtained from the literature, country observers, and investigated by the author as a member of the 1952 Australian Museum Expedition to central and north-western Australia, and on various field trips to western New South Wales.

III. The Species and their Relationships

The chats fall naturally into two groups, *Epthianura* (four species) and *Ashbyia* (one species, *lovensis*), the latter differing in a number of ways: It has acquired pipit-like habits of running and tail-wagging (partly developed in other species) and the unique habit of fluttering vertically into the air in the manner of song-larks (during courtship ?)—see description by McGilp (in Mathews 1922, p. 352). There is an increase in overall size and its bill is heavier. The colour pattern is drab and simple and there is no sexual dichromatism or bright " recognition marking" on the rump. It nests in holes in the ground instead of in bushes. These characteristics are, of course, direct adaptations to life on the bare and arid gibber deserts of the central region of Australia. However, they appear to represent a rather profound behavioural and ecological shift, hence the author follows Condon (1951) in retaining *Ashbyia* as a genus.

The four species of *Epthianura* are sexually dichromatic, having brilliantly coloured males and drab females. They are small, dainty birds that live in low bushes and samphire, and do much of their feeding on the ground in the open.

Each has a characteristic coloration and colour pattern, the dominant colours in the males being black and white in *E. albifrons*, red in *E. tricolor*, orange in *E. aurifrons*, and yellow in *E. crocea*. Differences, both morphological and ecological, are now such as to make it impossible to postulate where and how the different species originally arose.

IV. Taxonomy

(*a*) *Infraspecific Variation*

EPTHIANURA ALBIFRONS (Jardine & Selby)

(white-fronted chat)

Acanthiza albifrons Jardine and Selby, 1828, Illustrations of Ornithology, Vol. 2, pl. 56.

Distribution.—The southern half of Australia (excepting desert), ranging northwards to about Warwick, Qld., in the east, and Point Cloates, W.A., in the west. It is the only member of the genus occurring in Tasmania and along the well-watered continental seaboard of the east and south. The range is plotted in Figure 1.

Habitat.—Samphire and rush-covered margins of estuaries and rivers (on coast) and fringes of marshes and lakes (inland).

Geographic variation.—*E. albifrons* does not vary geographically in colour. When series are examined it is seen that birds from south-western Australia (e.g. Wilson's Inlet) are not "paler", nor are Tasmanian birds "darker" than the nominate form, as suggested by Mathews (1922).

Measurements of adult males and females from different parts of the range are set out in Table 1. The only dimension varying geographically is bill length, being approximately 6 per cent. larger in Tasmanian birds. This is confirmed by the measurements of female specimens. There is thus no doubt that the Tasmanian birds (*tasmanica* Mathews, 1912, (see Fig. 1, *B*), though differentiated to only a minor extent, are isolated and that Bass Strait is an effective barrier to gene flow.

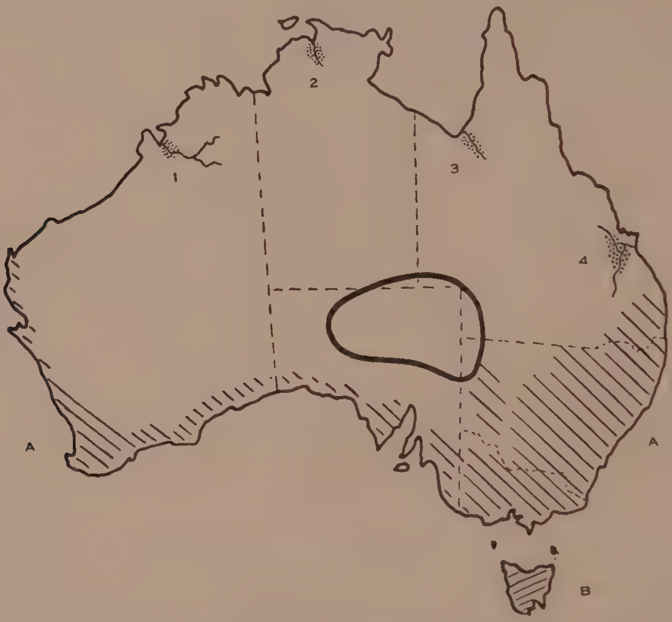

Fig. 1.—Range of *Epthianura albifrons* (indicated by cross-hatching), *E. crocea* (stippling), and *Ashbyia lovensis* (enclosed area). *A*, *E. a. albifrons*; *B*, *E. a. tasmanica*; 1, *E. c.boweri*; 2, *E. c. tunneyi*; 3, *E. c. crocea*; 4, *E. c. macgregori*.

Specimens seen.—QUEENSLAND: Emu Vale, near Warwick (5). NEW SOUTH WALES: Sydney area (35), Nevertire (6), Lachlan R. (7), Bourke (6). VICTORIA: Mallee area (11), Melbourne area (17). TASMANIA: Launceston and nearby areas (15), Flinders I. (1). SOUTH AUSTRALIA: Port Lincoln (6). WESTERN AUSTRALIA: Albany and Wilson's Inlet (14), Point Cloates (4). (Numbers in parenthesis indicate number of adults in series.)

EPTHIANURA TRICOLOR Gould

(crimson chat)

Epthianura tricolor Gould, 1841, Proc. Zool. Soc. Lond. **1840**: 159.

Distribution.—Australia generally, with the exception of the forested areas of the south, east, and north (see Figs. 2 and 3).

Habitat.—Inland plains dotted with clumps of bushes and tall grass, and open grassy areas in the savannah.

Geographic variation.—Nil.

Measurements of adult males from various parts of the range are set out in Table 2. All these specimens were collected during the spring, with the exception of some of the northern series which were taken in autumn and winter, most birds vacating these areas before spring.

E. tricolor has an eclipse plumage, brightly coloured males never, or only rarely, being seen during the winter months. This has been commented upon by various observers, especially Keartland (see North and Keartland 1896). No males in full breeding plumage were seen by the author in the many hundreds observed in central and north-west Australia during the winter of 1952. The sequence of plumage changes is not completely understood, although Soderberg (1918) has commented upon some aspects of the post-juvenile moult. Slight individual variation in the tone of the red in adult males is apparently correlated with length of time since the moult.

TABLE 2

SIZE VARIATION IN ADULT MALES OF EPTHIANURA TRICOLOR

Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
Normanton, Qld.	6	10·1–10·8 (10·7)	66–70 (68)	34–40 (36)
Minnie Downs, Qld.	2	10·4, 10·8	66, 69	36, 38
Western New South Wales	16	10·0–10·9 (10·5)	66–71 (69)	34–40 (37)
Pt. Augusta area, S.A.	8	10·0–10·8 (10·5)	67–71 (69)	34–38 (36)
Ayer's Rock, N.T.	1	10·4	70	41
Macdonnell Ranges, N.T.	10	10·0–10·9 (10·5)	68–71 (69)	36–39 (38)
Alexandria, N.T.	2	10·5, 10·6	68, 68	36, 37
Lake Way, W.A.	2	10·2, 10·8	68, 69	37, 38
Carnarvon area, W.A.	8	10·0–10·8 (10·4)	67–71 (69)	36–39 (38)
Maud's Landing, W.A.	2	10·6, 10·9	66, 68	37, 37
Forrest R. and Wyndham area, W.A.	6	10·4–10·9 (10·7)	66–71 (69)	35–41 (38)

Specimens seen.—QUEENSLAND: Normanton (9), Minnie Downs (3). NEW SOUTH WALES: Bathurst, Moree, Narrabri, and Bourke (32). SOUTH AUSTRALIA: Port Augusta and nearby localities (15), Ooldea (3). NORTHERN TERRITORY: Ayer's Rock (4), Macdonnell Ranges (16) Alexandria (5). WESTERN AUSTRALIA: Lake Way (5), Carnarvon area (12), Maud's Landing (4) Forrest R. and Wyndham (10).

EPTHIANURA AURIFRONS Gould
(orange chat)

Epthianura aurifrons Gould, 1838, Synopsis Birds of Australia. Pt. 4. App. 4.

Distribution.—Interior plains of the continent, extending to the coast where the climate is dry (i.e. Port Augusta and Great Australian Bight, S.A., and Point Cloates and Fitzroy R., W.A. During the record drought of 1902 the species invaded the Duaringa (near Rockhampton) area of Queensland, considerably farther to the east than previously recorded (Barnard and Barnard 1925).

Habitat.—Saltbush (mainly), the samphire belt around salt lakes, along the evanescent rivers and swamps of central Australia and where arid country extends to the coast, and also marine marshes.

Geographic variation.—Nil. The East Murchison and Alexandria populations, regarded as distinct by Mathews (1922) are seen to fall within the normal range of variation when a series is examined. Size likewise does not vary geographically (Table 3).

TABLE 3

SIZE VARIATION IN ADULT MALES OF EPTHIANURA AURIFRONS

Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
Inland New South Wales	12	9·6–10·4 (9·9)	64–67 (65)	33–38 (36)
Port Augusta, S.A.	8	9·5–10·3 (9·8)	63–66 (65)	33–37 (35)
Central Australia	4	9·5–10·4 (9·9)	63–67 (65)	33–39 (36)
Birdsville, Qld.	4	9·6–10·2 (9·8)	63–66 (64)	33–36 (35)
East Murchison, W.A.	2	9·7, 9·8	63, 64	34, 35
Carnarvon area, W.A.	8	9·6–10·1 (9·8)	63–66 (65)	34–36 (36)
Alexandria, N.T.	2	9·5, 9·6	63, 64	35, 36

It is not known for certain whether or not the colourful adult male plumage of *E. aurifrons* is retained during the winter, as the observations of Keartland (North and Keartland 1896) would indicate, or if there is an eclipse plumage. Hobbs records the winter flocks in the Deniliquin area as being composed of brown birds. Mr. N. J. Favaloro, who has frequently observed this species in winter in far-western New South Wales, has informed the author that he believes there is an eclipse plumage.

Specimens seen.—NEW SOUTH WALES: Various inland localities, including Broken Hill, Nyngan, Moree, Lachlan R., Booligal, Brewarrina, Darling R. (22). QUEENSLAND: Birdsville (7). SOUTH AUSTRALIA: Port Augusta (12), various localities in north adjacent to border with the Northern Territory, e.g. Oodnadatta, Wauta Pilla, Nakara (9). NORTHERN TERRITORY: Alexandria (3). WESTERN AUSTRALIA; East Murchison R. (5), Carnarvon area (15), odd specimens from Point Cloates, North West Cape, and Manilya.

EPTHIANURA CROCEA Castelnau & Ramsay

(yellow chat)

Epthianura crocea Castelnau and Ramsay, 1877, Proc. Linn. Soc. N.S.W. **1**: 380.

Distribution.—Known only from four widely separated river systems in the north of the continent: the Fitzroy R. in the Kimberleys, Alligator R. in Arnhem Land, Norman R., Gulf of Carpentaria, and Fitzroy R. in central eastern Queensland (Fig. 1). These localities are respectively 600, 700, and 800 miles apart. Whilst it is possible that the species will be found in additional places it is significant that many intermediate areas have been investigated ornithologically without the species having been recorded.

Habitat.—Bowyer-Bower (see Mathews 1922, p. 347) records that they are found in the Derby area in a kind of saltbush that grows in 4–5 in. of water near lagoons, but Keartland (see North 1904, p. 353) states that they are more at home in the branches of trees 15–20 ft high, searching for insects amongst the foliage, and are only occasionally seen on the ground. Near Normanton, Fletcher (see Mathews 1922 p. 348) records them as frequenting marshy and long grassy swamps. At Oenpelli, Alligator R., Deignan (personal communication) found them only in moist depressions on marshy plains surrounded by, or overgrown with, a rank stand of tall grass and leafless scrub. Their behaviour indicated extreme attachment to dense cover, the birds creeping about unseen in the tangled vegetation and, in the manner of fantail warblers, briefly exposing themselves at the tops of bushes.

Geographic variation.—There are four races differing from each other markedly in colour, as follows:

(i) *E. c. boweri* Mathews, 1922.—Fitzroy R., NW. Australia. This form is much duller in colour than the brightly coloured Alligator R. birds to the north. In the males the yellow of the top of the head is restricted to the forehead, fore-crown, and sides of the head, leaving the back of the head and anterior of the neck greyish brown, with a yellowish wash on some of the feathers. The back is an even brown, the feathers lacking the blackish markings and olive-yellow edgings. The yellow abdomen is pale and the chest bar a sooty grey smudge.

The females have the top of the head and the back brown and completely lack the pronounced olive wash of those from the Alligator R. The ventral surface is white, some of the feathers of the breast and abdomen being washed with pale yellow. The under-tail coverts are yellow.

(ii) *E. c. tunneyi* Mathews, 1912.—Alligator R., Arnhem Land. In adult males the whole of the head and anterior part of the back of the neck are golden. The back is dark (due to the centres of the back feathers being marked with black) and in addition the feathers are edged with olive-yellow. The ventral surface is a rich golden, with a prominent short black bar on the centre of the chest.

Females are decidedly more yellow throughout than those of the previous race.

(iii) *E. c. crocea* Castelnau & Ramsay, 1877.—Norman R., Gulf of Carpentaria. Males are darker above than those from Derby, approaching Alligator R. birds in this respect, but the black markings are somewhat reduced and the yellowish olive edges are lacking. The top of the head is olive-brown (i.e. not so yellowish as in Derby birds) and the side of the head is also darker. The yellow of the abdomen tends to be duller than that of the Alligator R. birds, but is richer than in Derby specimens. The breast band varies in each of the three specimens: in one it is long and narrow, in the second broader but shorter, in the third reduced to a small marking of lesser size than in the Derby birds. In all it is much less prominent than in the Alligator R. specimens.

The two female specimens approach closely those from the Alligator R. but though the back is equally dark it has only the faintest suggestion of olive. In one the throat is yellowish, in the other whitish. (An immature male is like the former but has a darkish smudge in the position of the future breast bar.)

(iv) *E. c. macgregori*, subsp. nov.—Fitzroy R. central eastern Qld. Two of the males from Fitzroy Vale have the back an even dark olive-brown but differ from the birds from Normanton, Qld., in their pronounced olive wash. The top of the head is like the back but brighter, though noticeably darker than in the Normanton birds. Ventrally they are as bright as those from the Alligator R. and have a prominent but narrow black breast band.

The single female from Fitzroy Vale is much more olive-yellow than those from Normanton. It is slightly darker above than the Alligator R. birds and has the same pronounced olive wash. The top of the head is like the back. The breast, including the throat (which is paler in the other females) is pronounced olive-yellow, slightly deeper than even in the Alligator R. birds.

TABLE 4

SIZE VARIATION IN ADULT MALES AND FEMALES OF EPTHIANURA CROCEA

Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
Adults males				
Derby, W.A.	3	10·2–10·4 (10·3)	60–62 (61)	35–37 (36)
Alligator R., N.T.	3	10·2–10·7 (10·4)	61–62 (62)	35–37 (36)
Normanton, Qld.	3	9·2– 9·5 (9·4)	61–62 (61)	33–36 (34)
Fitzroy Vale, Qld.	3	10·8–11·0 (10·9)	61–62 (61)	35–37 (36)
Adult females				
Derby	2	9·7, 10·2	59, 60	34, 36
Alligator R.	2	10·0, 10·2	60, 62	35, 35
Normanton	2	9·2, 9·3	59, 59	35, 36
Fitzroy Vale	1	10·6	61	35

It is interesting that this eastern population was actually the first to be sampled, a specimen being sent to the National Museum of Victoria by McGregor in 1859, 16 years before Castelnau and Ramsay described the nominate form from the Norman R. (Mack 1930). A member of it is figured in a coloured plate in *The Emu* (Campbell 1917), the bird figured having been collected at Torilla, some 90 miles north of Rockhampton, by Barnard and Berney.

It would seem appropriate to now give the east Queensland race the name of its original discoverer, so that it becomes *Epthianura crocea macgregori*, the original specimen (No. B 1572 in the National Museum of Victoria, Melbourne) becoming the type.

The distribution of the various races in *E. crocea* are set out in Figure 1. Measurements of specimens from different parts of the range are set out in Table 4. The number of specimens is far too small for adequate size comparison, but no variation is indicated. The bill could prove to be relatively short in Normanton, and long in Fitzroy Vale, birds.

Judging from the extent of their colour differences the four populations of *E. crocea* have been isolated for a fairly long time. They are today separated by extensive tracts of dry, open terrain.

Specimens seen.—WESTERN AUSTRALIA: Derby (5). NORTHERN TERRITORY: Alligator R. (5). QUEENSLAND: Normanton (5), Fitzroy Vale, inland from Rockhampton (4).

ASHBYIA LOVENSIS (Ashby)

(desert chat)

Epthianura lovensis Ashby, 1911, Emu **10**: 251.

Distribution.—Northern South Australia (north of lat. 31°S. (Terrill and Rix 1950) from about the Todmorden–Indulkina area north-west of Oodnadatta to Birdsville, Qld., and Broken Hill, N.S.W. (Fig. 1). A pair of birds, the only ones ever seen so far south, were collected at Sutherlands, S.A. (near Murray R.) in June, 1942 (E. F. Boehm, personal communication).

TABLE 5

SIZE VARIATION IN ADULT MALES OF ASHBYIA LOVENSIS

Locality	Sample Size	Bill Length (mm)	Wing Length (mm)	Tail Length (mm)
Indulkina, S.A.	2	10·8, 10·8	76, 76	38, 39
Leigh Creek, S.A.	4	10·6–10·9 (10·8)	73–76 (75)	36–40 (38)
Innamincka, S.A.	1	10·5	73	38
Birdsville, Qld.	4	10·6–10·9 (10·8)	73–76 (75)	37–40 (38)
Broken Hill, N.S.W.	2	10·6, 10·8	74, 76	38, 39

Habitat.—Arid gibber deserts and plateaux.

Geographic variation.—There is no geographic colour variation in this species, as has been noted by various authors, nor is there any evidence of size variation (see Table 5).

Specimens seen.—SOUTH AUSTRALIA: Innamincka (2), Mayers Well and Todmorden (2), Indulkina (3), Leigh Creek (6). QUEENSLAND: Birdsville (6), Wompah Gate (1). NEW SOUTH WALES: Broken Hill (3).

(*b*) *Nomenclature and New Synonymy*

Epthianura albifrons albifrons (Jardine & Selby), 1828. Synonym: *westralensis.*
Epthianura albifrons tasmanica Mathews, 1912.
Epthianura crocea crocea Castelnau & Ramsay, 1877.
Epthianura crocea boweri Mathews, 1922.
Epthianura crocea tunneyi Mathews, 1912.
Epthianura crocea macgregori, subsp. nov.
Epthianura tricolor Gould, 1841. Synonym: *assimilis.*
Epthianura aurifrons Gould, 1838. Synonym: *flavescens.*
Ashbyia lovensis (Ashby), 1911.

The forms *E. a. tasmanica* and *E. c. boweri* were wrongly reduced to synonymy by Mathews (1931).

V. Seasonal Movements, Breeding Areas, Isolation, and Geographic Variation

(a) *The Various Species Compared*

The seasonal movements of the various species may be summarized as follows:

(i) *E. crocea.*—Completely sedentary, its specialized marshy habitat apparently providing adequate conditions throughout the year. Taxonomic findings conclusively support distributional evidence that birds breed in the general area of their birth and that there is no interchange of individuals between the four isolated populations.

(ii) *A. lovensis.*—Relatively sedentary, never venturing beyond the restricted areas of gibber desert that constitute its habitat. It is obviously the best adapted member of the genus to aridity, and breeds after rain.

(iii) *E. albifrons.*—Nomadic over much of its range but apparently fairly sedentary in places. It commonly aggregates after the breeding season and under certain climatic conditions these flocks may reach considerable size (e.g. group of 2000 birds near Deniliquin in June, 1955 (J. Hobbs, personal communication)). It is a regular spring breeder. The numbers nesting in coastal districts are fairly constant but inland the spring population and distribution are dependent on environmental conditions. It is not known whether or not there is an interchange of individuals across the arid Nullarbor Plain, but this is possible as the south-eastern and south-western stocks are similar. Bass Strait forms a distributional barrier, cutting off a sedentary insular stock to the south.

(iv) *E. aurifrons.*—Moderately nomadic but movements vary with the area. Thus, in the south-east, it is a nomad only in dry years but in parts of the central desert its occurrence is quite irregular. The autumn movements would appear to lack the pronounced northward trend of those of *E. tricolor* for various field observers record flocks remaining throughout the winter in the southernmost parts of its range, e.g. Deniliquin area, N.S.W., during the winter of 1955 (J. Hobbs, personal communication), and in the far west of New South Wales (various years—N. Favaloro, personal communication). By contrast, however, Keartland (see North 1904, p. 351) states that there is an annual influx into the southern Kimberleys (junction of the Fitzroy and Margaret Rs.) from the south after the tropical rains in February.

(v) *E. tricolor.*—Highly nomadic and migratory, there being a seasonal shift in abundance from the south to the north of the continent.

In its seasonal movements and associated adaptations to a dry environment, it has a number of characteristics that must serve to restrict geographic variation and speciation. As these are also to be found, to an equal or lesser degree, in a number of unrelated bird species they will be analysed in detail in the next section.

The seasonal movements of the various species and their geographic variation are compared in Table 6. The development of the latter is obviously favoured by the sedentary habit, and rendered virtually impossible by the nomadic one.

(b) *The Adaptations of* E. tricolor *and their Influence on the Development of Geographic Variation*

(i) *Seasonal Movements—South–North Trends.*—The absence of *E. tricolor* from the southern parts of the continent in autumn and winter indicates a northward movement at the end of summer. Time of departure from New South Wales and Victoria is said to be the end of January or early February and their return is in October (North 1904). This movement is recognized in South Australia (Terrill and Rix 1950) and it likewise occurs, to some extent, in the west of the continent.

There is a prominent influx of the species into the far north of Australia in late summer and early autumn. Rogers (see Mathews 1922, p. 335), records their arrival in the Kimberleys in mid-February and states that they become steadily more numerous during the autumn until, with the exception of a few stragglers, all leave at the end of July. Soderberg (see Mathews 1922, p. 337) confirms this. On the opposite side of the continent, Berney (see Mathews 1922, p. 336) states of the Richmond district (upper Flinders R.), N. Qld., that, although members of the species are present throughout the year, an influx commences in March and they are most numerous in winter. There is at least one published observation (Whitlock 1924) of flocks on passage through the centre of the continent.

TABLE 6

SEASONAL MOVEMENTS AND GEOGRAPHIC VARIATION IN THE AUSTRALIAN CHATS (EPTHIANURA AND ASHBYIA)

Species	Seasonal Movements	Range		Geographic Variation and Isolation
		Size	Continuous or Discontinuous	
E. crocea	Nil	Extensive (peripheral)	Much broken up	Marked (4 distinctive isolates)
E. albifrons	Moderate on mainland	Extensive (peripheral and inland)	Essentially continuous on mainland, insular isolate	Slight, insular population somewhat distinct
E. aurifrons	Moderate	Extensive (inland)	Continuous	Nil
E. tricolor	Considerable	Extensive (inland)	Continuous	Nil
A. lovensis	Negligible	Very restricted (inland)	Continuous	Nil

The various localities from which *E. tricolor* has been recorded in autumn and winter, together with sources of the information, are set out in Table 7. These are plotted against the spring–summer breeding range in Figure 2. A pronounced shift in abundance from south to north at the end of summer, is disclosed, with no birds over-wintering south of about lat. 31° S. Spring–summer distribution, by contrast, is a southern one, with only a few birds remaining behind in the north.

The northward movement is presumably induced by the summer monsoon that sweeps over the north of the continent at this time, ensuring liberal plant growth and ample insects during the autumn and winter.

(ii) *The "Unpredictable" Element in the Movements.*—Though widely distributed over southern Australia in spring and summer the occurrence of *E. tricolor* in any

Table 7

AUTUMN–WINTER RECORDS OF EPTHIANURA TRICOLOR (SEE FIG. 2)

Reference No. on Figure 2	Locality	Observer	Reference
	South Australia		
1	Lake Frome	McGilp, J. N. (1923)	*Emu* **22**: 283
2	Mangeranie	Nicholls, E. D. B. (1923)	*Emu* **24**: 59
3	Musgrave and Everard Ranges	White, S. A. (1915) McGilp, J. N. (1935)	*Emu* **14**: 188 *Emu* **34**: 171
4	Nullarbor Plain	White, S. A. (1919)	*Emu* **18**: 177
	Hampton Tableland, Nullarbor Plain	McColl, W. S. (1929)	*Emu* **29**: 98
5	Wompah Gate, Qld.	Favaloro, N. J.	Personal observation large flocks, July 9, 1954
	Northern Territory		
6	Ayer's Rock	Keast, A.	Personal observation May, 1952. Skins in Aust. Mus. Coll.
7	Crown Pt., Finke R.	White, S. A. (1921)	*Emu* **21**: 94
8	Central Australia	North, A. J., and Keartland, G. A. (1898)	Rep. Horn Sci. Exp. Cent. Aust. Pt. 2.
	Missionary Plain	Whitlock, F. L. (1924)	*Emu* **23**: 267
9	Barrow Creek	Jarman, H. E. A. (1944)	*S. Aust. Orn.* **17**: 23
10	Tanami	Rogers, J. P. (in Gee 1911)	"General Report on Tanami Goldfield and District." p. 22. (Govt. Printer: Adelaide.)
11	Banka Banka Stn., between Tennant Creek and Newcastle Waters	Jarman, H. E. A. (1944)	*S. Aust. Orn.* **17**: 27
12	Borraloola	Barnard, H. G. (1914)	*Emu* **14**: 45
13	Brunette Downs	Barnard, H. G. (1914)	*Emu* **13**: 209
14	Alexandra	Ingram, C. (1907)	*Ibis* (9) **1** (3): 406
	Queensland		
15	Leichhardt R.	MacGillivray, W. (1929)	*Emu* **29**: 123
16	Mt. Isa	Jarman, H. E. A. (1944)	*S. Aust. Orn.* **17**: 45
17	Richmond, Upper Flinders R.	Berney, F. L. (in Mathews 1922)	"The Birds of Australia." Vol. 9. (H. F. and G. Witherby: London.)
18	Normanton	—	Skin in Amer. Mus. Nat. Hist. Coll.
19	Birdsville	—	Skin in Amer. Mus. Nat. Hist. Coll.
20	Winton, Longreach, Bulloo	MacGillivray, W. (1929)	*Emu* **29**: 123

TABLE 7 (*Continued*)

Reference No. on Figure 2	Locality	Observer	Reference
	Western Australia		
21	Carnarvon	—	Skins in Amer. Mus. Nat. Hist. Coll.
22	Upper Gascoyne R.	Carnaby, I. (1954)	*W. Aust. Nat.* **4**: 149
23	Pt. Cloates	Carter, T. (in North 1904)	"Nests and Eggs of Birds Found Breeding in Australia and Tasmania." Vol. 1. p. 347. (Aust. Mus.: Sydney.)
24	North West Cape	—	Skin in Amer. Mus. Nat. Hist. Coll.
25	Ullawarra	Robinson, A. H. (1954)	*W. Aust. Nat.* **4**: 187.
26 and 27	Broome, Derby, Meda, Hot Springs	Soderberg, R. (1918)	*K. Svenska VetenskAkad. Handl.* **52** (17): 1
28	Forrest R., near Wyndham	Keast, A.	Personal observation, June 1952. Skins in Aust. Mus. Coll.

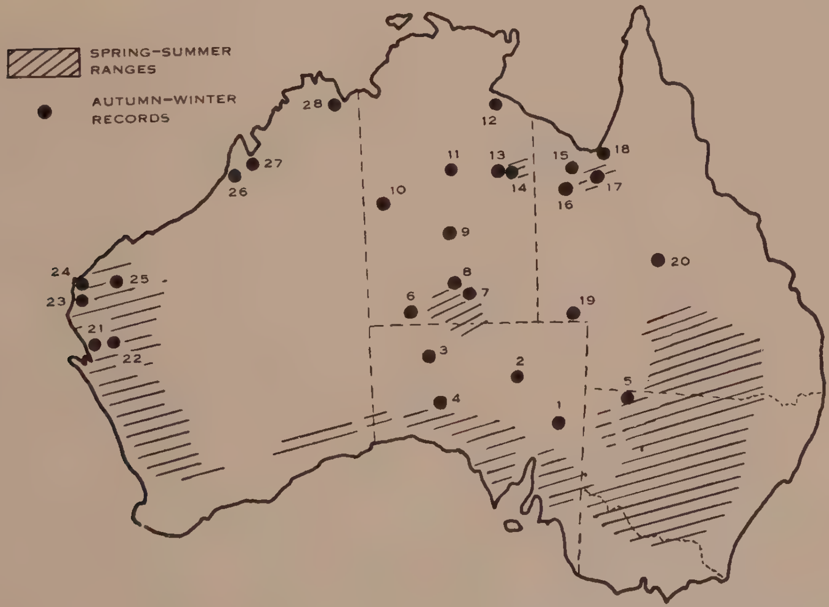

Fig. 2.—Spring–summer ranges (cross-hatching) and autumn–winter records (see Table 7) of *Epthianura tricolor*.

district is unpredictable, being strictly dependent on seasonal conditions. For example, at Cobborah, N.S.W., at the eastern extremity of range, Austin (see Mathews 1922, p. 334) states that members of the species appear in favourable springs and are then absent for years. The birds arrived and bred in the Bogan R. and Narran R. districts of central western New South Wales for the first time in 30 years during the severe drought of 1897 (North 1904). In the spring of 1954 there was a concentration of *E. tricolor* in the region of Cunnamulla, south-western Qld., following abundant winter rains and herbage growth, the first time they had occurred there in 5 years (M. Schrader, personal communication). In the west of the continent, Whitlock (1923) states that in the previous year they vacated the Fortescue–Hammersley area for the first time in years as a result of a drought. There was an "eruption" of the species into the Morawa district in the south-west corner of the continent, well to the south of their normal breeding range, during the spring of 1949 (White 1950).

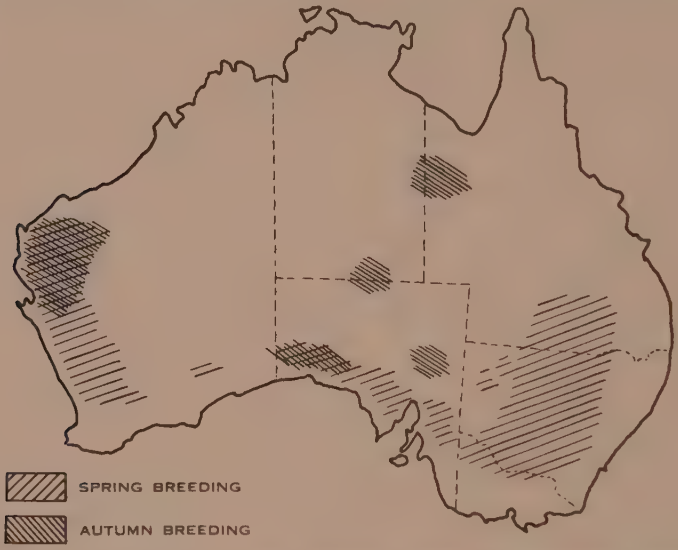

Fig. 3.—Spring and autumn breeding ranges of *Epthianura tricolor*.

E. tricolor could be said to approach the "ultimate" in the use of nomadism and seasonal movements as an adaptive device for coping with a dry and somewhat unpredictable environment. The fact that the movements are continent-wide, yet of irregular amplitude and, at least, to some extent multidirectional must serve to greatly intermix individuals from different areas.

(iii) *Reproduction in* E. tricolor.—Many birds inhabiting the interior of Australia are remarkably plastic with respect to time of breeding, it varying with rainfall (Keast and Marshall 1954). A survey of breeding areas and times of breeding indicates that *E. tricolor* has, in addition to the "normal" spring breeding in the better-watered regions of the south, an autumn breeding season, in association with rainfall, in the arid centre and in the north. The areas of the continent in which spring and autumn breeding have been recorded are contrasted in Figure 3. It will be noted that on the Nullarbor Plain and in the Hammersley–Fortescue section of Western Australia both can occur. Areas of recorded autumn breeding are as follows: Lake Frome, S.A. (McGilp 1923—many years residence in area); Illamurta, central Australia (Cowle—see North 1904, p. 348); Cloncurry, north Qld., "during wet seasons" (MacGillivray—see North 1904, p. 348); Gascoyne–Hammersley section of Western Australia (Carter—see North 1904, p. 349; Carnaby 1954; Robinson 1955); Nullarbor Plain, S.A. (McColl 1929). With respect to the occurrence of both spring and autumn breeding in the mid-west of the continent Carter states that breeding commences after the first winter rains in July but if there is summer rain the species breeds again in March, an observation confirmed by both Carnaby and Robinson. The authority for spring breeding on the Nullarbor Plain is Whitlock (1922).

The breeding habits of *E. tricolor* must serve to accelerate genetic intermixture in two ways. Firstly, in contrast with the "true" south–north migrants there are no regular breeding areas, the species is strictly an opportunist breeder so far as localities go. Hence individuals cannot occupy the same breeding territories from year to year. It is now known, as a result of banding work, that in various bird species the breeding territory forms an annual bond between the members of a pair, each tending to "home" to it at the end of winter—this bond is lacking in *E. tricolor*. Secondly, in a year when, in addition to the normal spring breeding in the south of the continent, there is autumn breeding in the centre and north a bird may, conceivably, pair the second time with an individual from one of these areas.

It is not, of course, known whether, in *E. tricolor*, breeding pairs tend to keep together during the autumn and winter, or if they simply disperse through the nomadic flocks. Likewise, the autumn breeding birds could equally be those that failed to breed in the spring, or did breed and have been stimulated again by unusually favourable conditions. Different flocks or age groups may be involved. Notwithstanding these possible limitations, however, a greatly accelerated gene flow would appear to be assured by the likelihood of young birds, pairing for the first time, accepting mates from other flocks and parts of the continent.

VI. Acknowledgments

The author wishes to thank the directors and ornithologists of the various museums (see Section II) whose specimens formed the basis of the taxonomic work, and to the various people who helped with ecological notes on the various members of the group under review.

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THE AUSTRALIAN CUTWORMS OF THE GENUS *AGROTIS* (LEPIDOPTERA: NOCTUIDAE)

By I. F. B. Common*

[*Manuscript received August* 28, 1957]

Summary

A taxonomic revision of the Australian cutworms, previously referred to *Agrotis* and *Euxoa*, has shown that nine valid species belong to *Agrotis* and none to *Euxoa*, which does not occur in Australia. A new species, *A. cygnea* from south-western Australia, is described. The wings and genitalia of each species are figured, and keys to the males and females provided.

Introduction

In the literature on the cutworms which affect pastures and cultivated crops in Australia, the names used by Hampson (1903) or Warren (1912), later slightly modified by Turner (1920), have usually been employed. In studying the distribution and pest status of these species, however, it soon became clear to the author that their identity and nomenclature have been greatly confused.

Hampson (1903) recognized seven Australian species in the genus *Euxoa* Hübner and five in the genus *Agrotis* Ochsenheimer, while Warren (1912) referred seven to *Euxoa* and seven to *Rhyacia* Hübner which included the genus *Agrotis* as defined by Hampson. Turner (1920) placed only four species in *Euxoa* and four in *Agrotis*, having assigned the remainder to other genera or reduced them to synonyms. In 1926 Turner described a fifth species of *Agrotis*, *A. poliophaea*, and in 1939 *Graphiphora ctenota* which also should have been referred to *Agrotis*.

In separating the genera of the Agrotinae (Noctuinae), Hampson placed great reliance upon the presence of spines and claws on the fore tibiae and upon the form of the frons. He distinguished *Euxoa* from *Agrotis* primarily by the shape of the frons and Warren (1912) used the same character to separate *Euxoa* and *Rhyacia*. Though Hampson also stated that in *Euxoa* the clasper of the male genitalia is bifurcate, he apparently disregarded this character in assigning the Australian species in which the clasper is never bifurcate. The genitalia of the species here referred to *Agrotis* are very similar to those of *A. segetum* (Schiffermuller), the type species, from the Palaearctic and Oriental regions.

A critical examination of the types of most of the Australian species and their synonyms, chiefly in the British Museum (Natural History) and the Muséum national d'histoire naturelle in Paris, has thrown much light on the identity of those of economic importance. Though important changes in the nomenclature of some of the species must follow, it is hoped that this study will lead to a stable and uniform usage of the names.

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The material examined came from the collections of the Department of Agriculture and Stock, Brisbane; the Australian Museum and the Department of Agriculture, Sydney; the National Museum of Victoria, Melbourne; the Tasmanian Department of Agriculture, Hobart; the South Australian Museum and the Waite Agricultural Research Institute, Adelaide; the Western Australian Department of Agriculture, Perth; the Division of Entomology Museum, C.S.I.R.O., Canberra; the British Museum (Natural History), the Hope Department, University Museum, Oxford, and the Muséum national d'histoire naturelle, Paris.

Genus AGROTIS Ochsenheimer

Agrotis Ochsenheimer, 1816, Die Schmetterlinge von Europa **4**: 66.

Type species *Noctua segetum* Schiffermuller.

Proboscis fully developed; labial palpi strongly oblique, 2nd segment with scales projecting strongly in front, apical segment porrect; frons rounded, sometimes with slight or distinct prominence, sometimes with slightly raised rim; eyes smooth; antennae in male bipectinate to beyond half, thence ciliated, in female sometimes minutely ciliated. Tibiae strongly spined (Fig. 1*B*). Valvae of male genitalia narrow, the sides nearly parallel, with corona and simple clasper; clavus present, hairy; vesica unarmed or with 1 or 2 scobinate patches. Bursa seminalis of female genitalia with parallel sides, forming a circular loop beside bursa copulatrix.

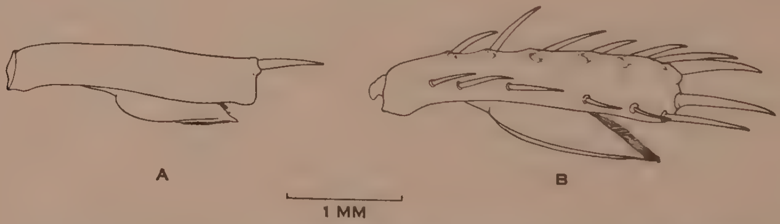

Fig. 1.—Fore tibia of: *A*, *Propatria mundoides* (Low.), and *B*, *Agrotis ypsilon aneituma* (Walk.).

Hübner (1806) first used the name *Agrotis* in the combination *Agrotis segetum* in the Tentamen which the International Commission on Zoological Nomenclature has added to the Official Index of Rejected and Invalid Works in Zoological Nomenclature (Opinion 278). The combination *Agrotis grata* appeared as a *nomen nudum* in Hübner's (1808) "Erste Zuträge zur Sammlung exotischer Schmetterlinge". In the text of the "Zuträge zur Sammlung exotischer Schmetterlinge", Hübner (1818) substituted the name *Elaphria grata*, associating it by number with a plate published earlier than the text. In Hemming's (1937) opinion the plate of the Zuträge validated the name *Agrotis grata* listed in the Erste Zuträge, though it was apparently Hübner's intention in the text of the Zuträge not to use the name *Agrotis* for this species. The name *Agrotis* was next used by Ochsenheimer (1816) for a group of species including *Noctua segetum*. As the name has been used consistently in this sense for more than a century, it would seem logical to add *Agrotis* Ochsenheimer, 1816, with type *Noctua segetum* to the Official List of Generic Names as suggested by Tams (1939).

The form of the valvae of the male genitalia readily distinguishes the genus *Agrotis* from other closely related genera such as *Noctua* L. which does not occur in Australia. *Euxoa*, with a strongly bifurcate clasper, is also not represented in the Australian fauna. In *Propatria* Hampson, 1903 and *Ectopatria* Hampson, 1903 the male valva has a clearly differentiated cucullus. The fore tibia of the latter is without spines, but in *Propatria* the tibia has a single distal spine (Fig. 1*A*).

The types of 31 of the names previously applied to Australian species of *Agrotis* came from Australia. All but two of these (*A. infusa* (Boisd.) and *A. vastator* (Scott)) have been examined, and the genitalia of most of them compared with other Australian material. Mr. D. S. Fletcher of the British Museum dissected the type of *Euxoa poliotis* Hampson and kindly sent the author a paratype which he considered to be identical with the type. In addition, two other species, *A. ypsilon* Hufnagel from Europe and *A. interjectionis* Guenée from Java, have been recorded from Australia. The type of the former has not been examined. Dr. M. Hering of the Berlin Museum states (personal communication) that no specimen of *A. ypsilon* is marked as the type and Hufnagel himself did not designate types. The type of *Noctua aneituma* Walker from the New Hebrides, erroneously placed in the synonymy of *Euxoa infusa* by Hampson (1903), has been examined and proves to be conspecific with Australian and New Zealand specimens referred to *A. ypsilon*. On behalf of the author, Mr. D. S. Fletcher also dissected the types of *A. interjectionis*, *A. orbicularis* Walker, and *A. significans* Walker, all from Java, and confirmed that the last two names are correctly placed in the synonymy of *A. interjectionis*.

Though the genitalia of the Australian species immediately show that they are correctly assigned to the genus *Agrotis*, considerable variation has been observed within species. This has made it very difficult to construct reliable keys for their identification. Not only does the wing pattern vary, but also characters of the frons, the male antennae, and the genitalia in both sexes. The kinds of variation occurring in structural characters are: the form and degree of development of the frontal prominence, the total number of segments and the number of segments in the filamentous apical portion of the male antennae, the relative length of antennal pectinations, the shape of the male valva and clasper, and the size and degree of development of the signa of the female bursa copulatrix.

The present revision of the Australian species of *Agrotis* refers them to nine species, one of which is described as new. As specimens of *A. ypsilon* from the south-west Pacific area, including Australia, differ consistently from typical Palaearctic specimens, they have been referred to the subspecies *aneituma* (Walker). This species and *A. infusa* together form one species group; *A. munda* Walker, *A. radians* Guenée, *A. cygnea*, sp. nov., *A. poliophaea*, and *A. interjectionis* form a second species group while *A. poliotis* (Hampson) and *A. porphyricollis* Guenée are rather more individual in character.

Five of the Australian species are probably confined to the southern half of the continent and two of these, *A. poliophaea* and *A. cygnea* have so far been recorded only from south-western Australia. *A. interjectionis* and *A. poliotis* are tropical species while *A. munda* is common throughout the continent.

A. munda, *A. infusa*, and *A. y. aneituma* are serious pests of field and vegetable crops and of pastures. In addition, *A. poliotis* and *A. interjectionis* have also been reported as pests. The larvae of five species are known, all of which attack plants at or near ground level, remaining hidden in the surface layer of the soil or beneath debris during the day.

KEY TO AUSTRALIAN SPECIES OF THE GENUS AGROTIS

Males

1. Valva with corona a series of strong tapering spines 2
Valva with corona absent or with a series of inconspicuous weak curved spines .... *A. poliotis* (Hamps.)

2(1). Vesica of aedoeagus with 2 dentate patches 3
Vesica of aedoeagus with less than 2 dentate patches 8

3(2). Forewing with most veins conspicuously outlined with light grey .... *A. radians* Guen.
Forewing with veins not conspicuously outlined with light grey 4

4(3). Hindwing entirely suffused with fuscous .... *A. poliophaea* Turn.
Hindwing white, sometimes with black terminal area beneath 5

5(4). Underside of hindwing white, sometimes with slight fuscous suffusion near apex 6
Underside of hindwing with broad black terminal area 7

6(5). Forewing dull greyish brown with indistinct markings .... *A. interjectionis* Guen.
Forewing light grey with distinct markings .... *A. cygnea*, sp. nov.

7(5). Forewing suffused with brown, markings thereby somewhat obscured .... *A. munda* Walk.
Forewing not suffused with brown, markings very distinct .... *A. cygnea*. sp. nov.

8(2). Forewing with tapering black bar between reniform spot and postmedial line, vesica of aedoeagus with 1 dentate patch 8
Forewing without black bar between reniform spot and postmedial line, vesica of aedoeagus without dentate patch .... *A. porphyricollis* Guen.

9(8). Forewing with black bar connecting orbicular and reniform spots, costal one-third of forewing not noticeably darker than remainder of wing .... *A. infusa* (Boisd.)
Forewing without black bar between orbicular and reniform spots, costal one-third of forewing strongly suffused with dark fuscous, much darker than remainder of wing .... *A. y. aneituma* (Walk.)

Females

1. Underside of hindwing white with very slight apical fuscous suffusion 2
Underside of hindwing with large black apical spot, or with broad distal fuscous suffusion 3

2(1). Forewing dull greyish brown with indistinct markings .... *A. interjectionis* Guen.
Forewing light grey with distinct markings .... *A. cygnea*, sp. nov.

3(1). Forewing with most veins conspicuously outlined with light grey .... *A. radians* Guen.
Forewing with most veins not conspicuously outlined with light grey 4

4(3). Hindwing white with fuscous distal suffusion 5
Hindwing more or less completely suffused with fuscous, though slightly paler basally 6

5(4). Forewing suffused with brown, claviform spot well developed .... *A. munda* Walk.
Forewing dark grey or fuscous, claviform spot inconspicuous .... *A. infusa* (Boisd.) (pale form)

6(4). Forewing with tapering black bar between reniform spot and postmedial line 7
Forewing without tapering black bar between reniform spot and postmedial line 8

7(6). Forewing with black bar connecting orbicular and reniform spots .... *A. infusa* (Boisd.) (dark form)
Forewing without black bar connecting orbicular and reniform spots .... *A. y. aneituma* (Walk.)
8(6). Bursa copulatrix with signum present .... *A. poliophaea* Turn.
Bursa copulatrix with signum absent 9
9(8). Underside of hindwing with apex conspicuously black, forewing not distinctly paler beyond postmedial line .... *A. porphyricollis* Guen.
Underside of hindwing with apex suffused with fuscous, not black; forewing distinctly paler beyond postmedial line .... *A. poliotis* (Hamps.)

DESCRIPTION OF SPECIES

AGROTIS YPSILON ANEITUMA (Walker)

Figs. 1*B*, 2*A*, 2*B*, 4*A*; Plate 1, Figs. 1 and 2

Noctua aneituma Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 701.

Rhyacia ypsilon Rottenburg, form *aneituma* Walker, Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 52.

Agrotis ypsilon Rottenburg, Meyrick, 1887, Trans. Proc. N.Z. Inst. **19**: 32; Meyrick, 1912, Trans. N.Z. Inst. **44**: 94; Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 131; Hudson, 1928, Butterflies Moths N.Z. p. 48, pl. 6, fig. 21.

Holotype.—A male labelled "New Hebrides, Aneiteum" (Agrotidae genitalia No. 562) in the British Museum (Natural History).

Male genitalia.—Valva much broader distally than at base, strongly curved near apex; corona with strong tapering spines; clasper slender, curved, acute; clavus small, inconspicuous; vesica of aedoeagus with single dentate ridge.

Female genitalia.—Ductus bursae, bursa copulatrix, and bursa seminalis slender, elongate; signum a well-developed oval thickened ridge; ostium a shallow cup.

Expanse.—Male 35·6–50·4 mm, female 42·0–55·6 mm.

Specimens examined.—66 ♂♂, 48 ♀♀.

Distribution.—Australia generally, common in eastern coastal districts. Also occurs in New Guinea, islands of the south-western Pacific, New Zealand, and Easter I. QUEENSLAND: Blackbutt, Brisbane, Clermont, Cunnamulla, Lake Barrine, Lamington National Park (3000 ft), Millaa Millaa, Mt. Tambourine, Roma. NEW SOUTH WALES: Jervis Bay, Lismore, Moruya, Murwillumbah, Narara, Sydney. SOUTH AUSTRALIA: Andamooka Ranges. WESTERN AUSTRALIA: Applecross, Bridgetown, Perth, Wyndham.

In addition to the holotype from the New Hebrides, specimens from Norfolk I. (Australian Museum), Lord Howe I. (C.S.I.R.O.), New Zealand (British Museum and Paris Museum), and New Guinea (C.S.I.R.O.) have been examined. Warren (1912) also recorded this subspecies from the Loyalty Is.

Comments.—Specimens of *A. y. aneituma* from Australia, New Zealand, and the south Pacific are distinguishable from typical Palaearctic specimens of *A. ypsilon* by the colour of the hindwings and the degree of dark fuscous suffusion in the forewings. Palaearctic specimens have pale, iridescent hindwings, whereas in *A. y. aneituma* they are heavily suffused with fuscous and only slightly iridescent. In the male of the latter, the costal one-third of the forewing is heavily suffused with dark fuscous while in the female the whole of the forewing, excepting the area between the postmedial and subterminal lines, is very much darker than in typical *A. ypsilon*. The genitalia of the two subspecies are indistinguishable.

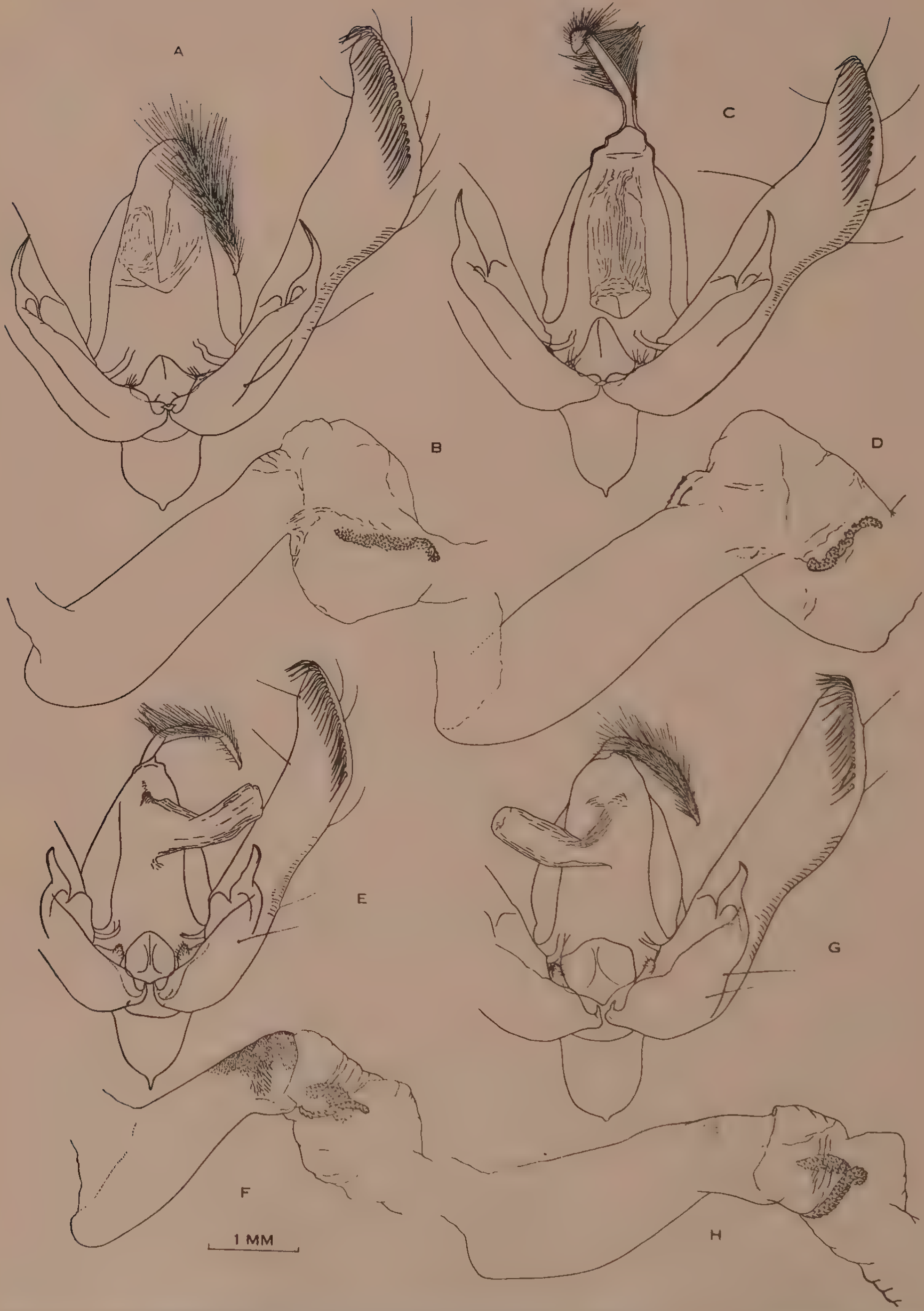

Fig. 2.—Male genitalia of: *A*, *B*, *Agrotis ypsilon aneituma* (Walk.); *C*, *D*, *A. infusa* (Boisd.) (dark form); *E*, *F*, *A. munda* Walk.; *G*, *H*, *A. radians* Guen.

No reliable genitalic character has been found for the separation of the females of *A. y. aneituma* and *A. infusa*. However, the shape of the juxta in the male genitalia is useful for distinguishing the two species. The forewing in both sexes of *A. infusa* is much more uniform in coloration than in *A. y. aneituma* which has a very pale area between the postmedial and subterminal lines. In the latter, the subterminal line is more strongly dentate and the intense black bar which connects the orbicular and reniform spots in *A. infusa* is absent. In living specimens, the underside of the abdomen is grey in both forms of *A. infusa*, but dull fuscous in *A. y. aneituma.*

A. y. aneituma and *A. infusa* may be readily distinguished from other Australian species by the genitalia in both sexes. The vesica of the aedoeagus in the male has 1 dentate patch, whereas in the remaining species 2 patches are present or they are both absent. The bursa copulatrix and bursa seminalis of the female are much longer and more slender than in most of the remaining species. However, the female genitalia of *A. porphyricollis* and *A. poliotis* are very similar to those of *A. infusa* and *A. y. aneituma*, but lack one or more signa which have been found invariably in the latter two species. In occasional specimens of *A. infusa*, only 1 small signum is present.

A. y. aneituma and *A. infusa* are closely related and, experimentally, will interbreed and produce fertile progeny (Common, unpublished data). The F_1 generation hybrids have characters intermediate between the two species. Although the areas of distribution of the two species overlap markedly, no natural hybrids have so far been recognized. There is little doubt therefore that *A. y. aneituma* and *A. infusa* are distinct species.

The larvae of *A. y. aneituma* are important pests of various field and vegetable crops in the coastal districts of Queensland and northern New South Wales. Diapause has not been recorded in the immature stages nor in the adult. As with *A. infusa* larval survival is favoured by heavy clay loams and clays; economic damage has been most frequently observed in crops grown on alluvial river flats. If sufficient moisture is available, however, damage may also occur to some extent on lighter soils.

The author has also examined specimens of *A. y. aneituma* taken in early February 1957 by Dr. R. Carrick (personal communication) flying around a ship during the day and at lights 300 miles from the west coast of New Zealand. This record suggests that the species is capable of long-distance movements.

AGROTIS INFUSA (Boisduval)

Figs. 2*C*–2*D*, 5*A*; Plate 1, Figs. 3–6

Noctua infusa Boisduval, 1838, Voy. L'Astrolabe, Lep. p. 240.

Agrotis spina Guenée, 1852, Hist. Nat. Ins., Spec. Gen. Lep., vi, Noctuelites **1**: 269 (type locality: Australia; holotype ♂ (genitalia slide No. 2917) in Paris Museum); Hampson, 1903, Cat. Lep. Phalaenae Brit. Mus. **4**: 367, pl. 68, fig. 27; Hudson, 1928, Butterflies Moths N.Z., p. 48, pl. 48, fig. 35.

Agrotis cordata Walker, 1857, List Lep. Ins. Coll. Brit. Mus. **11**: 741 (type locality: Australia; holotype ♂ (Agrotidae genitalia No. 557) in British Museum (Natural History)).

Agrotis nitida Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 668 (type locality: Moreton Bay, Qld.; holotype ♀ (Agrotidae genitalia No. 555) in British Museum (Natural History)).

Mamestra tenebrosa Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 669 (type locality: Sydney, N.S.W.; holotype ♀ (Agrotidae genitalia No. 556) in British Museum (Natural History)).

Agrotis vastator Scott, 1869, Trans. Ent. Soc. N.S.W. **2**: 40 (type appears to be lost).

Euxoa infusa Boisduval, Hampson, 1903, Cat. Lep. Phalaenae Brit. Mus. **4**: 164, pl. 60, fig. 8; Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 46, pl. 6a.

Rhyacia spina Guenée, Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 52, pl. 8a.

Agrotis infusa Boisduval, Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 131.

Holotype.—It is neither in the British Museum (Natural History) nor in the Muséum national d'histoire naturelle, Paris. According to Boisduval the type locality is Australia.

Male genitalia.—Valva much broader distally than at base, strongly curved near apex; corona with strong tapering spines; clasper slender, curved, acute; clavus small, inconspicuous; vesica of aedoeagus with single dentate ridge.

Female genitalia.—Ductus bursae, bursa copulatrix, and bursa seminalis slender, elongate; signum usually a well-developed oval thickened ridge, sometimes a second less-sclerotized signum present, occasionally only a single, very poorly developed signum; ostium a broad shallow cup.

Expanse.—Dark form: male 40·4–50·4 mm, female 40·0–54·0 mm. Pale form: male 32·0–46·4 mm, female 31·6–50·0 mm.

Specimens examined.—Dark form: 141 ♂♂, 101 ♀♀; pale form: 78 ♂♂, 50 ♀♀.

Distribution.—Southern Australia, south of the Tropic of Capricorn. Hudson (1928) also records it from New Zealand.

Dark form.—QUEENSLAND: Brisbane, Bunya Mts., Cunnamulla, Forest Hill, Milmerran, Montville, Roma, Warwick. NEW SOUTH WALES: Barrington Tops (4200 ft), Broken Hill, Gosford, 20 miles W. of Gundagai, Gunnedah, Jervis Bay, Lake Cargelligo, Lawson, Moruya, Mt. Kosciusko (5000–6000 ft), New England, 65 miles N.W. of Nyngan, Ourimbah, Savernake, Sydney, Trangie, Wagga, Wollongong, Yanco, Yetman. AUSTRALIAN CAPITAL TERRITORY: Canberra, Mt. Gingera (6000 ft). VICTORIA: Benalla, Birchip, Black Rock, Bogong, Cowes, Eltham, Gisborne, Grampians (3800 ft), Kiewa House, Melbourne, Mt. Buffalo, Mt. Hotham (6000 ft), 30 miles N. of Orbost. SOUTH AUSTRALIA: Adelaide, Belair, Cooper Crossing, Fraser Range, Kyancutta, Marree, Mt. Painter (Flinders Range), Ooldea. TASMANIA: Elliott, Geeveston, Hobart, Launceston, Scottsdale. WESTERN AUSTRALIA: Carnarvon, Katanning, Nungarin.

Pale form.—NEW SOUTH WALES: Jervis Bay, Narara, Sydney, Trangie. AUSTRALIAN CAPITAL TERRITORY: Canberra. VICTORIA: Birchip, Gisborne, Melbourne, Montrose, Wandin. SOUTH AUSTRALIA: Adelaide. WESTERN AUSTRALIA: Forrest, Katanning.

Comments.—Although it has not been possible to locate the type of *A. infusa*, Boisduval's description almost certainly refers to the typical form with dark hindwings. The types of *A. spina*, *A. nitida* and *M. tenebrosa* belong to the typical form and the type of *A. cordata* to the pale form.

The frons of *A. infusa* is usually rounded as in *A. y. aneituma* (Fig. 5*A*), but sometimes there is a very slight prominence. The pectinations of the male antennae are somewhat variable in length and very similar to those of *A. y. aneituma*.

The typical form of *A. infusa*, with dark hindwings, occurs mainly in the spring and summer while the pale form, with whitish hindwings, occurs from May until August. Specimens indistinguishable from each form, as well as various intermediates, have been reared experimentally from both parent forms (Common, unpublished data). The genitalia of the two forms are indistinguishable, though some variation occurs in each. Large populations of the typical form migrate in the spring to the highlands of south-eastern Australia where they aestivate in small caves and crevices in rock outcrops at altitudes above 4000 ft (Common 1954). The pale form has not been observed aestivating.

In January and February 1957, when conditions were exceptionally dry, very small specimens of about 30 mm expanse were taken near Canberra. These specimens had hindwings of an intermediate shade. Similarly, about the same time, exceptionally small specimens of several other noctuids, including *A. munda*, were common.

In late winter and early spring the larvae of *A. infusa* cause serious damage to pastures and to a wide range of crops including wheat, barley, linseed, lucerne, potatoes, cabbages, cauliflowers, silver beet, and peas. Damage is most severe to pastures and crops growing on heavy clay loams, clays, and alluvial soils on the tablelands, western slopes, and western plains of south-eastern Australia.

AGROTIS MUNDA Walker

Figs. 2*E*–2*F*, 4*B*, 5*B*; Plate 2, Figs. 1 and 2

Agrotis munda Walker, 1856, List Lep. Ins. Coll. Brit. Mus. **10**: 348.

Mamestra basinotata Walker, 1858, List Lep. Ins. Coll. Brit. Mus. **15**: 1686 (type locality: Moreton Bay, Qld.; holotype ♀ (Agrotidae genitalia No. 547) in British Museum (Natural History)).

Agrotis turbulenta Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 703 (type locality: Moreton Bay, Qld.; holotype ♀ (Agrotidae genitalia No. 548) in British Museum (Natural History)).

Agrotis injuncta Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 703 (type locality: Adelaide, S.A.; holotype ♀ (Agrotidae genitalia No. 549) in British Museum (Natural History)).

Agrotis scapularis Felder, 1874, Reise Novara, pl. 110, fig. 13 (type locality: Australia; holotype ♀ (Agrotidae genitalia No. 606) in British Museum (Natural History)).

Euxoa radians Hampson, 1903 (non Guenée), Cat. Lep. Phalaenae Brit. Mus. **4**: 164, pl. 60, fig. 7; Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 46, pl. 6a; Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 133; Hudson, 1928, Butterflies Moths N.Z. p. 47, pl. 6, fig. 25.

Holotype.—A male labelled "Adelaide, Australia, Wilson" (Agrotidae genitalia No. 546) in the British Museum (Natural History).

Male genitalia.—Valva broader distally, curved to apex, corona with strong tapering spines; clasper curved with rounded apex; clavus prominent; vesica of aedoeagus with 2 dentate patches.

Female genitalia.—Bursa seminalis equal in diameter to narrowest portion of bursa copulatrix; signum a small oval thickened ridge, sometimes a second much less conspicuous sclerotized patch; ostium a deep cup with sloping sides.

Expanse.—Male 28·0–42·0 mm, female 30·8–42·4 mm.

Specimens examined.—140 ♂♂, 182 ♀♀.

Distribution.—Throughout Australia, especially in inland areas. QUEENSLAND: Aramac, Brisbane, Charleville, Clermont, Cunnamulla, Eidsvold, Eungella, Gayndah, Gordonvale, Herbert R., Inglewood, Jericho, Meringa, Quilpie, Rockhampton, Springsure, Stradbroke I., Tolga, Westwood, Yelarbon, Yeppoon. NEW SOUTH WALES: Albury, Beecroft, Broken Hill, Dorrigo East, Glen Innes, Grafton, Hay, Hunter R., Huonbrook, Jervis Bay, Maitland, Narara, 10 miles SE. of Savernake, Sydney, Terrigal, Trangie, Wallerawang, Wanaaring, Warrah, Williams R., Yanco.

AUSTRALIAN CAPITAL TERRITORY: Canberra. VICTORIA: Beaconsfield, Benalla, Bendigo, Birchip, Castlemaine, Gisborne, Little Desert, Mount Buffalo, Nhill, Sea Lake. TASMANIA: Devonport, Elliott, north-east Tasmania, Strahan. SOUTH AUSTRALIA: Adelaide, Andamooka Ranges, American River (Kangaroo I.), Ardrossan, Belair, Fisher, Flinder's Chase (Kangaroo I.), Hughes, Kingscote (Kangaroo I.), Lake Eyre, Kyancutta, Marree, Mt. Painter (Flinders Range), Musgrave Ranges, Ooldea, Wynbring. WESTERN AUSTRALIA: 16 miles S. of Borden, Bridgetown, 10 miles S. of Bridgetown, Carnarvon, Coolgardie, Forrest, Fremantle, Margaret R., Monte Bello I., Nornalup, 10 miles W. of Nornalup, Perth, 5 miles N. of Pinjarra, Roebourne, Scarborough, Sherlock R., Wandagee, Wandering, Wyndham, Yallingup, Yampi Sound, Yanchep. NORTHERN TERRITORY: Alexandria, Alice Springs, Anthony Lagoon, Ayer's Rock, Brock's Creek, MacDonnell Ranges, Mt. Liebig, Newcastle Waters, Tennant Creek, 14 miles N. of Tyon Station. Also from New Caledonia (Paris Museum), Friendly Is. and Norfolk I. (British Museum), New Zealand (Hudson 1928) and Cocos–Keeling Is. (C.S.I.R.O.)

Comments.—Owing to an unfortunate error by Hampson (1903), this important pest species has been known in the Australian literature for many years as *Euxoa radians* (Guen.). Boursin's (1928) paper, which drew attention to this error, has been overlooked previously by Australian workers. Though the type of *A. radians* in the Paris Museum bears a label "vu par G. F. Hampson, 1902," Hampson redescribed and figured *A. munda* under this name.

The species group to which *A. munda* belongs may be separated from the *A. infusa* group by the vesica of the male aedoeagus which, in the former, bears 2 dentate patches, whereas in the latter it has only 1. The female bursa copulatrix and bursa seminalis in the *A. munda* group are relatively shorter and thicker than in the *A. infusa* group, or in either *A. poliotis* or *A. porphyricollis*. From *A. radians* and *A. poliophaea*, *A. munda* may be distinguished by the much whiter hindwing, and by the forewing, which is suffused with brown. The forewing of *A. radians* is broader and the veins are clearly outlined with light grey. The pectinations of the male antennae are much shorter in *A. munda* than in other species of the *A. munda* group. It is closely related to *A. cygnea* which has whiter hindwings, lacks the brown suffusion of the forewing, and has longer pectinations of the male antennae. In *A. interjectionis* the antennal pectinations are also longer and not so distinctly fasciculated as in *A. munda*. The underside of the hindwing of the former is almost pure white, whereas in *A. munda* there is a large black apical spot.

The larva of *A. munda*, known as the brown cutworm, is a destructive pest of many field and vegetable crops, especially those grown on light soils (Currie 1931). It resists desiccation surprisingly well during spring and summer when sheltering in the dry and dusty surface layer of many of the cultivated soils of subcoastal and inland districts.

AGROTIS RADIANS Guenée

Figs. 2*G*, 2*H*, 4*C*, 5*C*; Plate 2, Figs. 3 and 4

Agrotis radians Guenée, 1852, Hist. Nat. Ins., Spec. Gen. Lep. vi, Noctuelites **1**: 261. Boursin, 1928, Encycl. Ent., Ser. B. III. Lep. **3**(4): 50, pl. iv, fig. 2.

Agrotis repanda Walker, 1857, List Lep. Ins. Coll. Brit. Mus. **11**: 742 (type locality: Australia; holotype ♀ British Museum (Natural History)).

Euxoa repanda Walker, Hampson, 1903, Cat. Lep. Phalaenae Brit. Mus. **4**: 163, pl. 60, fig. 6. Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 46, pl. 6a. Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 133.

Lectotype.—A male labelled "Tasmanie" (genitalia slide No. 2916), in Muséum national d'histoire naturelle, Paris. Lectotype selected by Viette (1951).

Male genitalia.—Valva slightly broader distally, corona with strong tapering spines, clasper curved with rounded apex, clavus prominent; vesica of aedoeagus with 2 dentate patches.

Female genitalia.—Bursa seminalis thicker in diameter than narrowest portion of bursa copulatrix; signum a strong elliptical thickened ridge and 1 or 2 less-conspicuous sclerotized ridges; ostium a shallow rounded cup.

Expanse.—Male 37·6–44·4 mm; female 38·8–45·0 mm.

Specimens examined.—25 ♂♂, 11 ♀♀.

Distribution.—QUEENSLAND: Milmerran. NEW SOUTH WALES: 9 miles W. of Braidwood, Gosford, Shoalhaven R. AUSTRALIAN CAPITAL TERRITORY: Blundell's (3000 ft), Canberra (1900 ft). TASMANIA: Devonport, Kingston.

Comments.—The species is not well represented in collections, but will probably prove to be fairly widely distributed in northern Tasmania, eastern Victoria, the south coast and the tablelands of New South Wales, and southern Queensland. The larva has not so far been recorded as a pest.

The conspicuous light grey outlining of most of the veins in the forewing of both sexes distinguishes the species quite readily from other Australian species. In addition the hindwing is much darker than in *A. cygnea*, *A. munda*, and *A. interjectionis*, in which the hindwings are white, at least in the basal half. In the male of *A. radians*, the antennal pectinations are longer than in any other Australian species except *A. porphyricollis*, from which it may be distinguished by the markings of the forewing, the presence of 2 dentate patches in the vesica of the aedoeagus and, in the female, by the relatively short and thick bursa copulatrix in which the signa are well developed.

AGROTIS CYGNEA, sp. nov.

Figs. 3*A*, 3*B*, 4*D*, 5*D*; Plate 2, Figs. 5 and 6

Types.—Holotype male (genitalia slide No. N208), allotype female (genitalia slide No. N181), and one male paratype labelled "Nedlands W.A. 23.4.52, J. A. Mahon, light trap"; one male paratype "Katanning, W.A., 20 Apr. 1950, J. A. Mahon"; one female paratype "Claremont, Apr. 30, 1912, W.B.A."; all in the Division of Entomology Museum, C.S.I.R.O., Canberra. One male paratype "Beverley, W.A., F. H. du Boulay", in South Australian Museum, Adelaide; one male and one female paratype "Sth. Perth, W.A., 8.5.52, C. F. H. Jenkins" in the collection of the Western Australian Department of Agriculture; one female paratype "Perth, W.A., Matthews" in the British Museum (Natural History).

Male (holotype).—Head light grey, face white; labial palpi white, basal two-thirds of 2nd segment and outer side of basal segment black, irrorated with white; frons with slight prominence; antenna with 55 proximal segments bipectinate, 16 distal segments filamentous, pectinations long, fasciculate; stem of antenna white, slightly irrorated with black towards base. Thorax grey with slight ochreous brown suffusion, tegulae ochreous on anterior third, bordered above by slight fuscous irroration, patagia light grey, indistinctly edged with ochreous and fuscous; legs with femora and tibiae white, irrorated with dark grey, tarsal segments dark fuscous with white apices. Abdomen whitish above and below, irrorated with fuscous, suffused with dark fuscous laterally. Forewing white, suffused with grey; 3 dark fuscous bars on basal third and 2 more on apical third of costa; a large, broadly oval ochreous spot near base, between *Cu* and anal vein, with white margin, its anterior and posterior edge black; claviform black with brownish suffusion; orbicular spot oval, white with fuscous centre and narrow black edge; reniform spot large, dark fuscous, ringed with

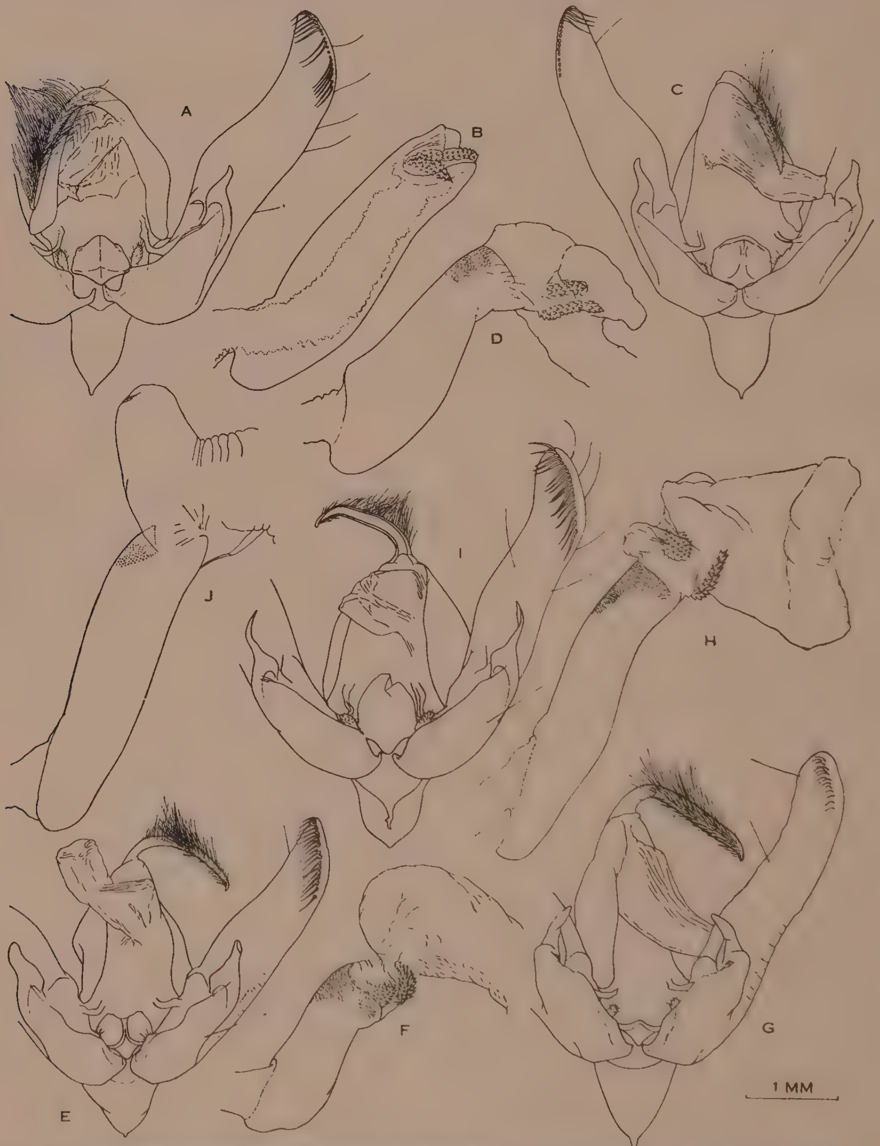

Fig. 3.—Male genitalia of: *A*, *B*, *Agrotis cygnea*, sp. nov., holotype; *C*, *D*, *A. poliophaea* Turn., holotype; *E*, *F*, *A. interjectionis* Guen.; *G*, *H*, *A. poliotis* (Hamps.); *I*, *J*, *A. porphyricollis* Guen.

white and with narrow black margin; area between orbicular and reniform spots black; postmedial line indistinct, dark fuscous, outward curved, from three-fifths costa to three-quarters dorsum; subterminal line from just before apex to tornus, with strong outward dentations on R_5, M_3, Cu_1, and Cu_2; area just preceding postmedial line and between postmedial line and termen suffused with dark fuscous; a series of black triangles on termen between veins; cilia brownish ochreous with darker medial line. Hindwing white, translucent, slightly iridescent; veins slightly fuscous towards margin; narrow fuscous suffusion on termen, slightly broader at apex; cilia white, fuscous at apex and with medial darker fuscous line towards apex. Underside of forewing white, suffused with fuscous in outer fifth, termen outlined with black, fuscous suffusion on costa and in cell, cilia whitish suffused with fuscous; underside of hindwing white, small dark fuscous apical spot, termen narrowly outlined with black; cilia white, suffused with fuscous at apex.

Female (*allotype*).—Similar to male but paler, forewing with less grey suffusion, and with fuscous suffusion confined to veins and to area beyond subterminal line; claviform ochreous brown, with some black scales; area between orbicular and reniform spots suffused with ochreous brown and with a few scattered ochreous brown scales beyond reniform spot; hindwing and underside of both wings paler than in male.

Male genitalia (*holotype*).—Valva not enlarged distally, corona with strong tapering spines, clasper curved with rounded apex, clavus prominent; vesica of aedoeagus with 2 dentate patches.

Female genitalia (*allotype*).—Bursa seminalis thicker in diameter than narrowest portion of bursa copulatrix; signum a lightly sclerotized scobinate patch; ostium a small rounded cup.

Expanse.—Male 35·0–39·0 mm; female 38·0–40·0 mm.

Specimens examined.—5 ♂♂, 4 ♀♀.

Comments.—Some male specimens have much greyer forewings than the holotype, though the markings are still very clearly defined. The ochreous edge to the patagia and the large ochreous spot near the base of the forewing may be brown. The species can be distinguished from *A. munda* by the more distinct markings of the forewing, the absence of the brown suffusion, and by the much whiter and less iridescent hindwing, which usually has a much narrower dark margin and smaller apical spot than in *A. munda*. However, as the apical spot on the underside of the hindwing in some specimens is almost as large and dark as that found in *A. munda*, *A. cygnea* appears in two couplets of the key. The pectinations of the male antennae are longer than in *A. munda* and *A. poliophaea*, yet shorter than in *A. radians* and *A. porphyricollis*. The genitalia show that it is nearest *A. radians* and *A. poliophaea*. From the former it may be separated by the shape of the juxta and the valva. Moreover the hindwings are white in *A. cygnea* but heavily suffused with fuscous in *A. radians*. The hindwings of *A. poliophaea* are also dark.

AGROTIS POLIOPHAEA Turner

Figs. 3*C*, 3*D*; Plate 2, Figs. 7 and 8

Agrotis poliophaea Turner, 1926, Trans. Roy. Soc. S. Aust. **50**: 120.

Holotype.—A male labelled "Merredin, W. Australia, L. J. Newman" (genitalia slide No. N141) in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Male genitalia (*holotype*).—Valva not enlarged distally, corona a series of moderate tapering spines (most lost from holotype), clasper curved with slightly rounded apex; clavus moderate; vesica of aedoeagus with 2 dentate patches.

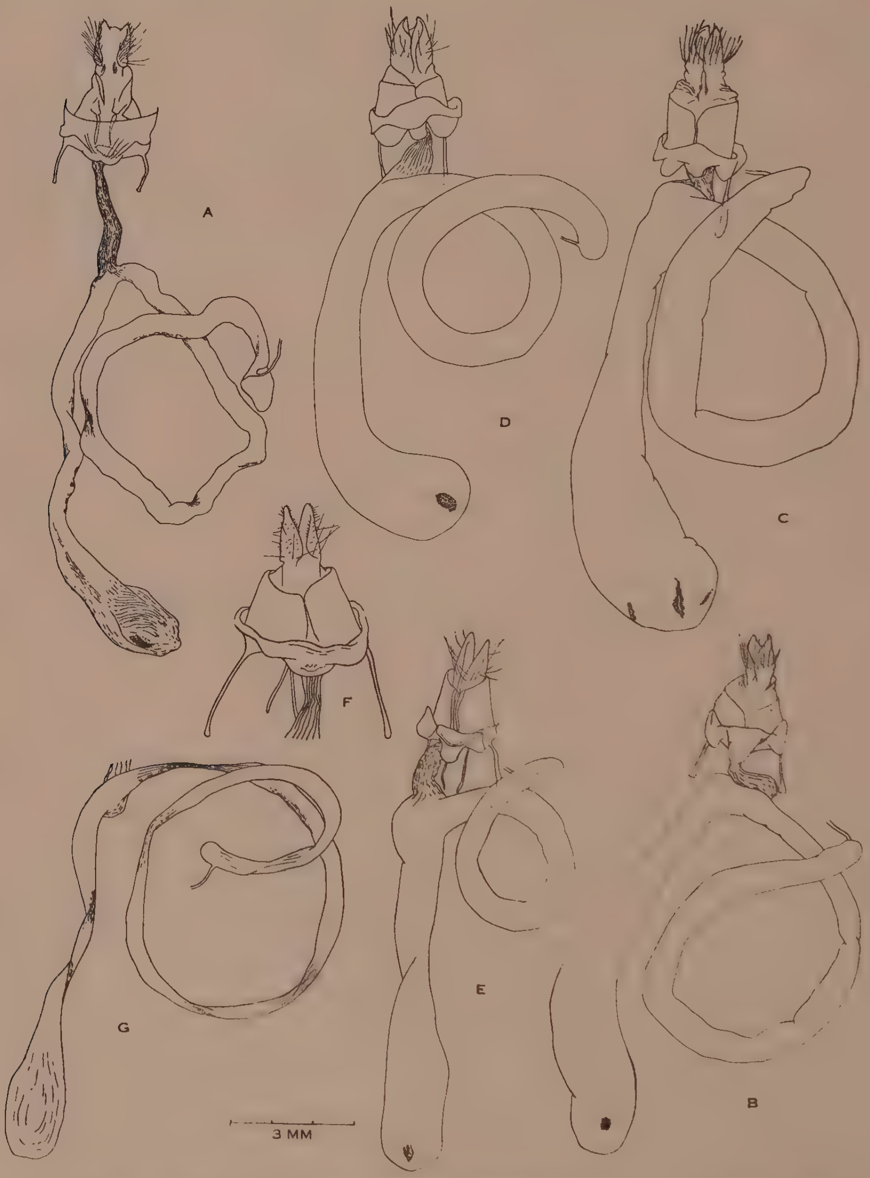

Fig. 4.—Female genitalia of: *A*, *Agrotis ypsilon aneituma* (Walk.); *B*, *A. munda* Walk.; *C*, *A. radians* Guen.; *D*, *A. cygnea*, sp. nov., allotype; *E*, *A. interjectionis* Guen.; *F*, *G*, *A. poliotis* (Hamps.).

Comments.—The species is based upon the unique male type in which the right valva of the genitalia is broken. A series of six very damaged specimens, recently collected in a light trap near Perth by officers of the Western Australian Department of Agriculture, may prove to be conspecific. As the male genitalia differ from the type rather more than might be expected in intraspecific variation, further material, preferably from the type locality, is required before the identity of these specimens can be confirmed.

Turner's original description requires supplementing as follows: the male antenna has the proximal 54 segments bipectinate and the remaining 16 filamentous. The pectinations are long and are strongly fasciculate. The frons is produced into a slight prominence. The holotype has a wing expanse of 36·8 mm.

The holotype is an inconspicuous insect with poorly defined markings. The dull fuscous grey hindwing distinguishes it from other species in the *A. munda* group except *A. radians*. From the latter it may be separated by the shorter pectinations of the male antennae and by the forewing, which in the latter has the veins conspicuously outlined with light grey. The genitalia of the male show that the species is not as closely related to *A. poliotis* as Turner (1926) supposed.

AGROTIS INTERJECTIONIS Guenée

Figs. 3*E*, 3*F*, 4*E*, 5*E*; Plate 3, Figs. 1 and 2

Agrotis interjectionis Guenée, 1852, Hist. Nat. Ins. Spec., Gen. Lep. vi, Noctuelites **1**: 281.
Agrotis orbicularis Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 700 (type locality: Java; holotype ♀ (Agrotidae genitalia No. 938) British Museum (Natural History)).
Agrotis significans, Walker, 1865, List Lep. Ins. Coll. Brit. Mus. **32**: 700 (type locality: Java; holotype ♂ (Agrotidae genitalia No. 937) British Museum (Natural History)).
Euxoa interjectionis Guenée, Hampson, 1903, Cat. Lep. Phalaenae Brit. Mus. **4**: 166, pl. 60, fig. 11; Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 48, pl. 6d. Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 133.

Holotype.—A female labelled "Java, Horsfield, E.I.C. 60:15" (Agrotidae genitalia No. 676) in the British Museum (Natural History).

Male genitalia.—Corona a series of well-developed marginal spines, clasper stout with blunt apex, clavus small; juxta without prominent vertical ridge; vesica of aedoeagus with 2 dentate patches.

Female genitalia.—Bursa copulatrix with signum a thickened oval ridge, bursa seminalis narrower in diameter than narrowest portion of bursa copulatrix, in a single small loop; ostium a deep cup with sloping sides.

Expanse.—Male 29·0–37·6 mm, female 33·6 mm.

Specimens examined.—7 ♂♂, 2 ♀♀.

Distribution.—Indonesia, New Guinea, and Northern Australia. NORTHERN TERRITORY: Brock's Creek.

Comments.—Hampson's (1903) description of this species is adequate to distinguish it from other Australian species. The underside of the hindwing is white, without a terminal dark fuscous or black fascia. The hindwing of *A. poliotis* is also white but is not translucent or slightly iridescent as in *A. interjectionis*. These are the only two Australian species with the underside of the hindwing lacking a definite apical spot. They can be best separated from each other by the genitalia in both sexes. In *A. interjectionis*, the corona of the male valva is much more strongly developed and the female bursa seminalis is much shorter than in *A. poliotis*.

Kalshoven (1950–51) records this species as a pest of several tropical crops in Indonesia though its relative importance is not clearly established. Later it may prove troublesome to an expanding agriculture in the Northern Territory.

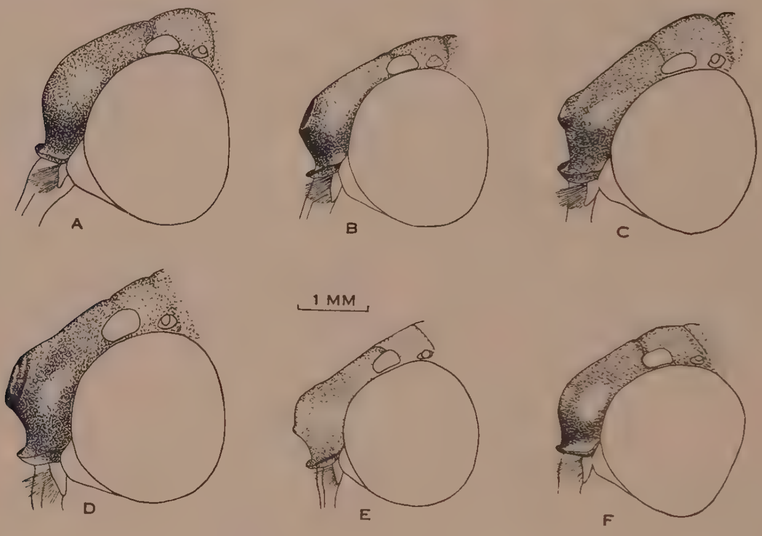

Fig. 5.—Heads of Australian species of *Agrotis*, showing the form of the frons. *A*, *A. infusa* (Boisd.); *B*, *A. munda* Walk.; *C*, *A. radians* Guen.; *D*, *A. cygnea*, sp. nov.; *E*, *A. interjectionis* Guen.; *F*, *A. poliotis* (Hamps.).

AGROTIS POLIOTIS (Hampson)

Figs. 3*G*, 3*H*, 4*G*, 5*F*; Plate 3, Figs. 3 and 4

Euxoa poliotis Hampson, 1903, Cat. Lep. Phalaenae Brit. Mus. **4**: 184, pl. 60, fig. 22.

Euxoa poliotis perfusa Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 49, pl. 6e (type locality: Roebourne, W.A.; holotype ♀ in British Museum (Natural History)).

Agrotis bromeana Aurivillius, 1920, Ark. Zool. **13**(2): 16, pl. 1, fig. 6 (type locality: Broome, W.A.; holotype ♀ in Naturhistoriska Riksmusseet, Stockholm).

Agrotis poliotis Hampson, Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 133.

Holotype.—A male labelled "Townsville, 1900 Sep." (Agrotidae genitalia No. 985) in the British Museum (Natural History).

Male genitalia.—Valva not enlarged distally; corona absent or present as a series of weak inconspicuous curved submarginal spines; clasper stout with blunt apex; clavus well developed; juxta without medial vertical ridge; vescia of aedoeagus with 2 dentate patches.

Female genitalia.—Bursa copulatrix without signum; bursa seminalis long, slender, in diameter rather less than narrowest portion of bursa copulatrix; ostium a broad shallow cup.

Expanse.—Male 29·6–39·2 mm, female 36·0–44·0 mm.

Specimens examined.—18 ♂♂, 18 ♀♀.

Distribution.—Coastal and subcoastal districts of northern Australia, as far south as the southern Queensland border. QUEENSLAND: Ayr, Banks I., 65 miles W. of Burketown (Turnoff Lagoon), Cairns, Charters Towers, Dimbulah, Home Hill, Innisfail, Kuranda, Noosa, Sandgate, Southport, Thursday I., Townsville. WESTERN AUSTRALIA: Broome, Manbulloo Station, Roebourne, Wyndham. NORTHERN TERRITORY: Larrimah.

Comments.—The male valva, with the corona reduced or absent, at once separates *A. poliotis* from other Australian species. As in *A. interjectionis*, the underside of the hindwing lacks a black apical spot. However, the female hindwing on both surfaces is sometimes strongly suffused with fuscous. Unlike females of the *A. munda* group, the genitalia have a long slender bursa seminalis as in *A. y. aneituma*, *A. infusa*, and *A. porphyricollis*. The absence of the signum distinguishes *A. poliotis* and *A. porphyricollis*, but no reliable character has been found to separate the female genitalia of these two species. They may be identified by the underside of the hindwing, which in *A. poliotis* lacks the conspicuous black apical area, although sometimes suffused with fuscous.

The degree of pigmentation of both wings, especially in females, varies considerably. The type of *A. bromeana*, from north-western Australia, is a dark female with with hindwings suffused with fuscous. Similarly Warren's subspecies *perfusa* from this area is figured as a small dark female. However, similar variation has been observed also in specimens from north Queensland.

May and Passlow (1954) record that the larvae of *A. poliotis* sometimes injure crops in Queensland, but are seldom of economic importance.

AGROTIS PORPHYRICOLLIS Guenée

Figs. 3*I*, 3*J*; Plate 1, Figs. 7 and 8

Agrotis porphyricollis Guenée, 1852, Hist. Nat. Ins., Spec. Gen. Lep. vi, Noctuelites **1**: 259.

Perigea albinasus Walker, 1856, List Lep. Ins. Coll. Brit. Mus. **10**: 276 (type locality: Australia; holotype ♀ (Agrotidae genitalia No. 558) British Museum (Natural History)).

Agrotis rubrilinea Walker, 1856, op. cit. **10**: 351 (type locality: unknown; holotype ♂ (Agrotidae genitalia No. 559) British Museum (Natural History)).

Agrotis recondita Walker, 1856, op. cit. **10**: 351 (type locality: Tasmania; holotype ♀ (Agrotidae genitalia No. 561) British Museum (Natural History)).

Graphiphora reclusa Walker, 1856, op. cit. **10**: 403 (type locality: Australia; holotype ♂ (Agrotidae genitalia No. 550) British Museum (Natural History)).

Agrotis dorsicinis Walker, 1858, op. cit. **15**: 1701 (type locality: Moreton Bay; holotype ♂ (Agrotidae genitalia No. 551) British Museum (Natural History)).

Graphiphora lapidosa Walker, 1858, op. cit. **15**: 1707 (type locality: New South Wales; holotype ♀ Hope Department, University Museum, Oxford).

Spaelotis pectinata Walker, 1865, op. cit. **33**: 707 (type locality: Moreton Bay; holotype ♂ (Agrotidae genitalia No. 554) British Museum (Natural History)).

Elegarda orthosioides Walker, 1865, op. cit. **33**: 712 (type locality: Moreton Bay; holotype ♂ (Agrotidae genitalia No. 553) British Museum (Natural History)).

Tetrapyrgia graphiphorides Walker, 1865, op. cit. **33**: 712 (type locality: Tasmania; holotype ♂ (Agrotidae genitalia No. 560) British Museum (Natural History)).

Elegarda summa Walker, 1865, op. cit. **33**: 713 (type locality: Tasmania; holotype ♂ (without abdomen) British Museum (Natural History)).

Hadena albipalpis Walker 1865, op. cit. **33**: 741 (type locality: Moreton Bay; holotype ♀ (Agrotidae genitalia No. 552) British Museum (Natural History)).

Agrotis transversa Walker, 1869, Char. Undescr. Lep. Heter. p. 70 (type locality: unknown; holotype ♀ (abdomen damaged) National Museum, Melbourne).

Agrotis baueri Felder, 1874, Reise Novara, pl. 110, fig. 10 (type locality; Australia: holotype ♂ (Agrotidae genitalia No. 607) British Museum (Natural History)).

Euxoa porphyricollis Guenée, Hampson, 1903, Cat. Lep. Phalaenae Brit. Mus. **4**: 165, pl. 60, fig. 9; Warren, 1912, in Seitz, Macrolep. World, II, Indo-Aust. Fauna **11**: 47, pl. 6b; Turner, 1920, Trans. Roy. Soc. S. Aust. **44**: 133.

Graphiphora ctenota Turner, 1939, Proc. Roy. Soc. Qd. **50**: 142 (type locality: Scone, N.S.W.; holotype ♂ (genitalia slide No. N139) C.S.I.R.O.) (syn. nov.).

Lectotype.—A male labelled "Australie" (genitalia slide No. 2915) in Muséum national d'histoire naturelle, Paris. Lectotype selected by Viette (1951).

Male genitalia.—Spines of corona well developed, clasper curved, acute, clavus prominent, hairy; juxta elongate, sides nearly parallel, without prominent vertical ridge; vesica of aedoeagus without dentate patches.

Female genitalia.—Bursa copulatrix long, slender, without signum; bursa seminalis about equal in diameter to narrowest portion of bursa copulatrix.

Expanse.—Male 32·4–40·0 mm, female 34·4–47·2 mm.

Specimens examined.—159 ♂♂, 114 ♀♀.

Distribution.—Coastal and subcoastal Australia, south of the Tropic of Capricorn. QUEENSLAND: Brisbane, Bunya Mts., Gympie, Mt. Tambourine, Stanthorpe, Toowoomba. NEW SOUTH WALES: Colo Vale, Guyra, Jervis Bay, Lithgow, Narara, Mt. Kosciusko, Scone, Shoalhaven R., Sydney, Tenterfield, Tubrabucca, Wallerawang. AUSTRALIAN CAPITAL TERRITORY: Canberra. VICTORIA: Black Rock, Castlemaine, Gisborne, 9 miles S. of Kiata, Inverloch, Macedon, Melbourne, Moe, Wandin, Wingan. TASMANIA: Cressy, Devonport, Elliott, Hobart, Launceston, Ridgeway, Snug R., Waratah. SOUTH AUSTRALIA: Adelaide. WESTERN AUSTRALIA: 16 miles S. of Borden, 10 miles S. of Bridgetown, Busselton, Carnarvon, Collie–Cardiff, Dowerin, Harvey, Katanning, Lennox, Merredin, Narrogin, Perth, Quairading, Stirling Range, Tammin, Waroona, Warren R., Yanchep.

Comments.—The long pectinations of the male antennae distinguish this species readily from all but *A. radians*. The conspicuous outlining of the veins, characteristic of the forewing of *A. radians*, never occurs in *A. porphyricollis*. In the latter the vesica of the aedoeagus lacks any ornamentation, whereas in the remaining species there are 1 or 2 dentate sclerotized patches. As in *A. poliotis* the bursa copulatrix is without a signum. The underside of the hindwing separates it from that species.

The forewing of *A. porphyricollis* shows great colour variation. The ground colour ranges from whitish to rich brown, through various shades of ochreous, bluish grey, and light brown. The markings, which vary from fuscous to reddish brown, are very indistinct in some specimens and the ground colour predominates. In others the ground colour is almost entirely obscured by a dense fuscous irroration. Some of the latter retain a narrow fascia of the pale ground colour between the subterminal line and the termen. The lectotype has dull ochreous grey forewings with inconspicuous markings and Turner's type of *Graphiphora ctenota* is rather similar. This remarkable range of variation has been largely responsible for the lengthy synonymy.

The larvae of *A. porphyricollis* have been recorded by May and Passlow (1954) as a minor pest of field crops in Queensland. In south-eastern Australia they are not uncommon in pastures, attacking dicotyledonous herbage or weeds, and in south-western Australia specimens have been recorded attacking weeds on a golf course.

Acknowledgments

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Explanation of Plates 1–3

Plate 1

Fig. 1.—*Agrotis ypsilon aneituma* (Walk.), male, Canberra.

Fig. 2.—*A. y. aneituma* (Walk.), female, Canberra.

Fig. 3.—*A. infusa* (Boisd.), male, dark form, Yetman, N.S.W.

Fig. 4.—*A. infusa* (Boisd.), female, dark form, Canberra.

Fig. 5.—*A. infusa* (Boisd.), male, pale form, Canberra.

Fig. 6.—*A. infusa* (Boisd.), female, pale form, Canberra.

Fig. 7.—*A. porphyricollis* Guen., male, Canberra.

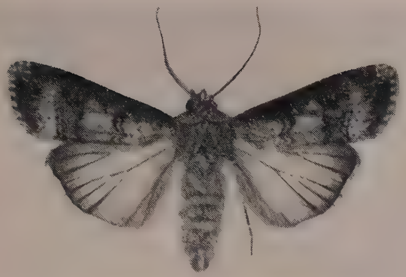
Fig. 8.—*A. porphyricollis* Guen., female, Canberra.

PLATE 2

Fig. 1.—*A. munda* Walk., male, Canberra.
Fig. 2.—*A. munda* Walk., female, Canberra.
Fig. 3.—*A. radians* Guen., male, 9 miles W. of Braidwood, N.S.W.
Fig. 4.—*A. radians* Guen., female, 9 miles W. of Braidwood, N.S.W.
Fig. 5.—*A. cygnea*, sp. nov., holotype male, Nedlands, W.A.
Fig. 6.—*A. cygnea*, sp. nov., allotype female, Nedlands, W.A.
Fig. 7.—*A. poliophaea* Turn., upperside of holotype male, Merredin, W.A.
Fig. 8.—*A. poliophaea* Turn., underside of holotype male.

PLATE 3

Fig. 1.—*A. interjectionis* Guen., upperside of male, Brock's Creek, N.T.
Fig. 2.—*A. interjectionis* Guen., underside of male in Plate 3, Figure 1.
Fig. 3.—*A. poliotis* (Hamps.), male, Charters Towers, Qld.
Fig. 4.—*A. poliotis* (Hamps.), female, Cairns, Qld.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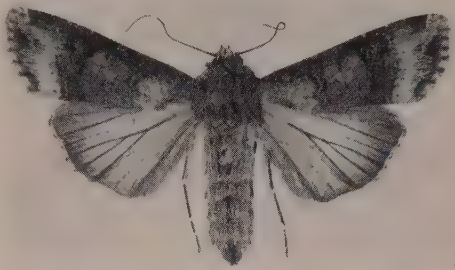
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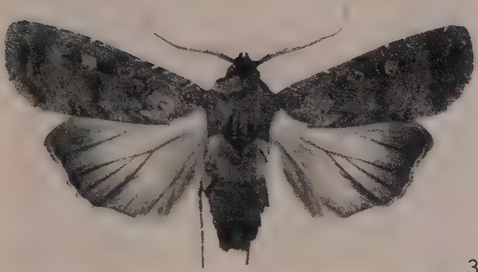
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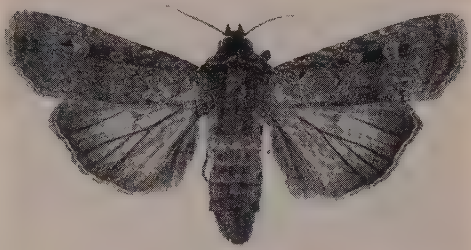
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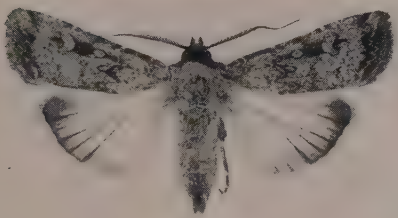
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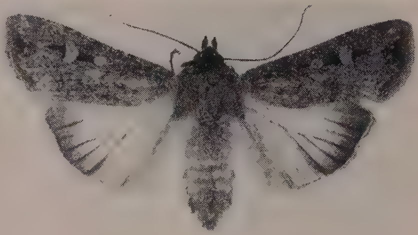
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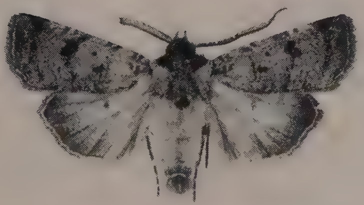
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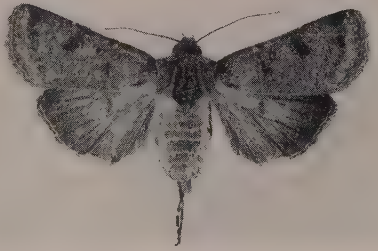
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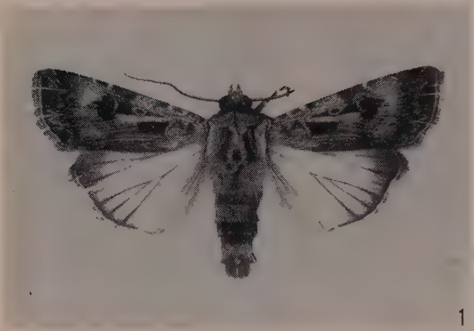
AUSTRALIAN CUTWORMS OF THE GENUS AGROTIS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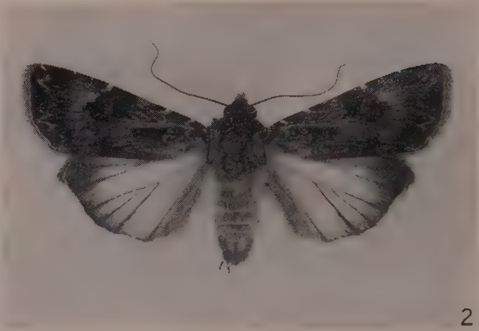
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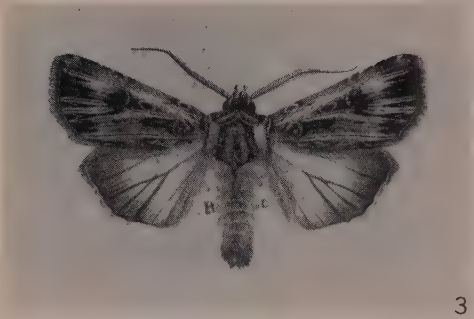
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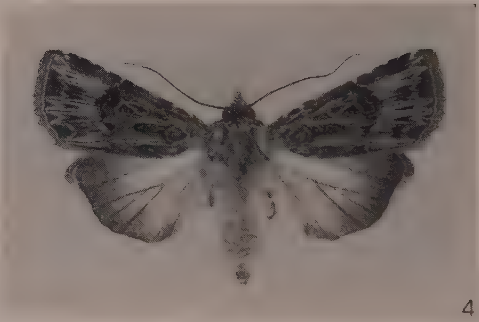
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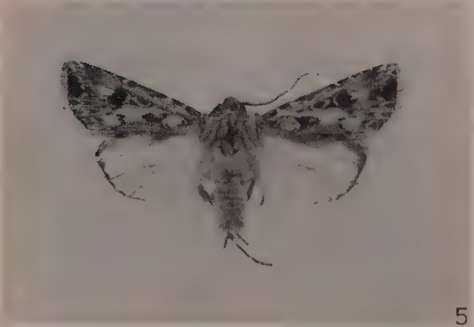
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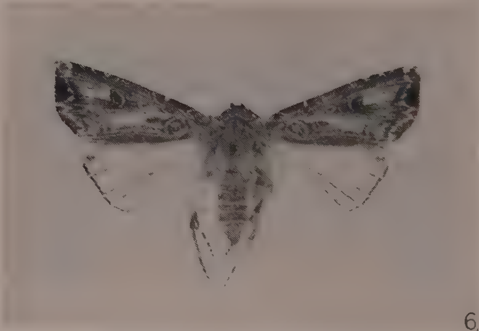
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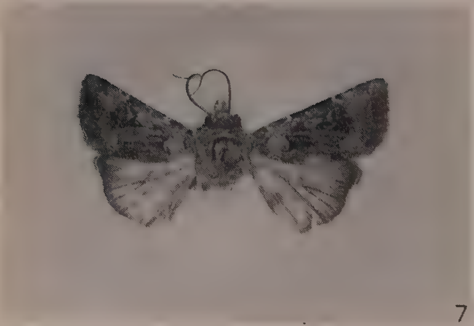
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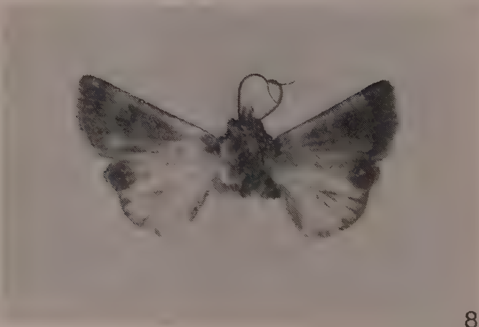
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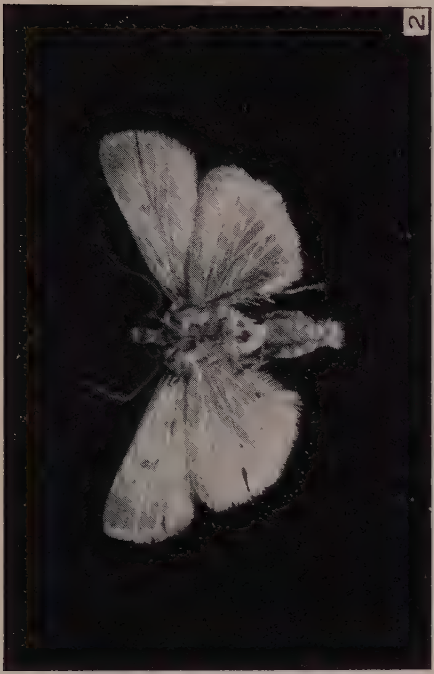
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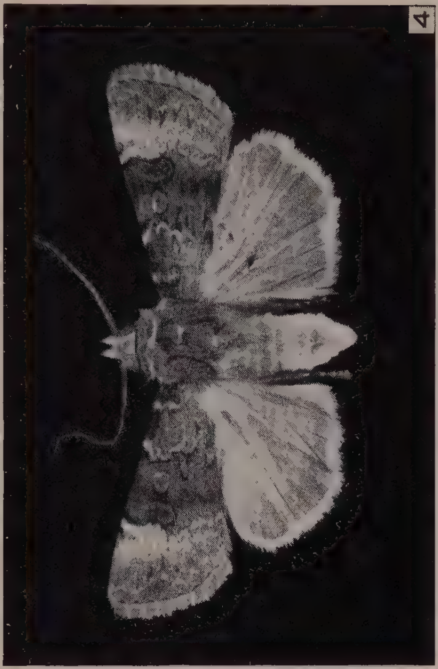
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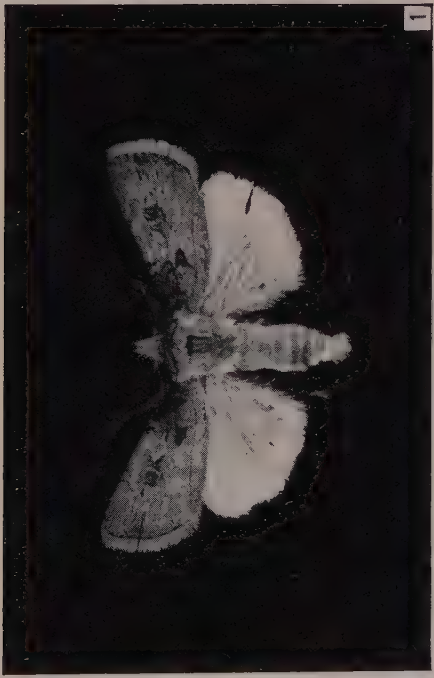
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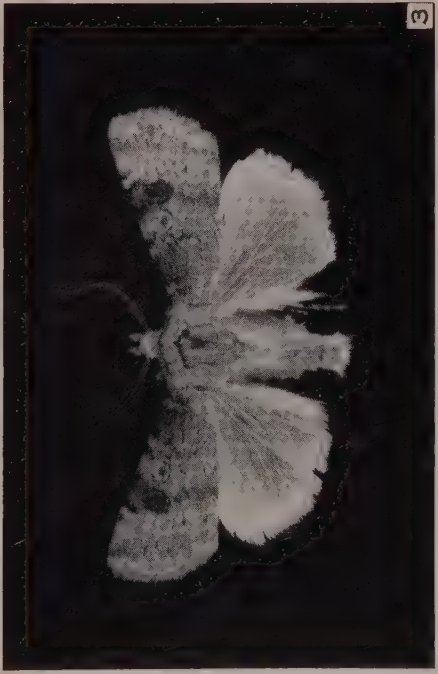
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A REVIEW OF AUSTRALIAN PYRGOTIDAE (DIPTERA)

By S. J. Paramonov*

[*Manuscript received November* 4, 1957]

Summary

The last review of Australian pyrgotids was that of Bezzi (1929) to which Malloch added an appendix. Since 1929 accumulated material includes representatives of 7 new genera and 37 new species. The number of Australian pyrgotids is now 67 species distributed in 18 genera. Practically all representatives of this family are nocturnal. The larvae are endoparasitic upon lamellicorn beetles, but nothing has been published about the life history of the Australian species.

Introduction

Since publication in 1929 of a posthumous paper by Bezzi, with an appendix by Malloch, no paper has been published on the Australian Pyrgotidae, giving a false impression that our knowledge of the pyrgotid fauna is virtually complete.

This paper shows very clearly that the study of the Australian Pyrgotidae is only in its initial steps. The fact that pyrgotids are nocturnal is one reason for their comparative rarity in collections. Usually only odd specimens were collected by various collectors and the richness of this family in Australia is not reflected by the bulk of material in museums.

The author has been able to make progress only because Mr. I. F. B. Common, Division of Entomology, C.S.I.R.O., has made regular light-trap collections over a number of years in the Canberra area, and has discovered a large number of new forms of pyrgotids. This method of collecting is the only satisfactory one for this group. Occasional night collecting in Western Australia has shown that the discovery of many new species and possibly genera can be expected there, but scarcely any collecting of pyrgotids has been done in Western Australia. This paper therefore stresses the necessity of a more detailed study of the family.

It has been suspected that most pyrgotids are parasites of scarabaeid beetles and that they are an important factor in regulating the numbers of the beetles which are defoliators of eucalypts. Recently Common and Straatman (personal communication) observed females of *Frontalia noctua*, sp. nov. and *Prodalmannia variabilis* Bezzi apparently attempting to oviposit upon adult beetles of *Phyllotocus macleayi* Fisch. (Scarabaeidae). The beetles and the flies were crawling within 12 in. of a 160-W lamp suspended over a sheet. A pyrgotid, with ovipositor curved forward beneath its body, would follow a beetle for a few seconds before darting at it. After the brief scuffle which ensued, the fly would become disinterested and proceed to wipe its ovipositor with its tarsi. However, subsequent examination of the beetles failed to reveal any eggs. This appears to be the first observation of this kind of behaviour in pyrgotids and strongly indicates that they are parasitic upon adult beetles of the family Scarabaeidae.

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The females are highly specialized for attacking the beetles; they all have an extremely strong, long, chitinized ovipositor of variable shape, often longer than the rest of the abdomen. To grasp the beetles, they have special adaptations, such as bifurcated claws in the genus *Osa*, gen. nov., or strong brushes of hairs or bristles on coxae or trochanters (in some *Epicerella* species)—characters which usually are found in males, but in pyrgotids the males are devoid of these.

The discovery of new genera and a rather large number of new species has forced the author to construct new keys for identification. New characters have been introduced, as identification based only on the characters used by Bezzi and Malloch are not always definitive.

The close relationship between the faunas of New Guinea and of the Cape York area makes it desirable to include in this paper two New Guinean pyrgotids, which probably can be found in the Cape York area also.

Eighteen genera now are reported from Australia, seven of them being new (*Adapsona*, *Commoniella*, *Facilina*, *Musgravena*, *Osa*, *Paratoxura*, *Pyrgella*). The number of species (including three New Guinean) is 67, 37 of them being new.

CHARACTERIZATION OF THE FAMILY

The Pyrgotidae belong to the group so-called Muscidae Acalyptratae and was formerly regarded as a subfamily of Ortalidae. Although this family has some forms transgressive to the ortalids, it consists of a rather uniform monophyletic group, having not only morphological but also biological features in common. The adults are night-flying insects; the larvae have endophagous habits, living in the bodies of Coleoptera and Hymenoptera.

The Pyrgotidae belongs to group A of Hendel's (1922) classification, i.e. the costa is complete, without one or two weak points at humeral vein and apex of subcostalis, although in some species the costa is nearly bare and close to the humeral cell (but not broken and thin as in groups B and C). Subcostalis well developed. Vibrissae quite absent. Tibiae without pre-apical dorsal bristle. Radialis haired or bristled. Propleural bristle absent. Lower angle of anal cell acute and usually produced, but there are forms with a straight vein closing the anal cell. 1–3 supra-alar bristles. Penis spiral; ovipositor usually very large, solid, and always greatly swollen at base, sometimes longer than the remainder of abdomen.

Separation from the Platystomidae is difficult. Only the dorsally depressed ovipositor in Platystomidae separates them easily from the females of pyrgotids, which always have very swollen ovipositors. The squamae alares in pyrgotids are always poorly developed, whereas in Platystomidae they are usually large (acalyptrate with very well-developed calypters!). The prelabrum in Platystomidae is large, but in the Pyrgotidae it is small.

KEY TO THE AUSTRALIAN GENERA OF PYRGOTIDAE

1. Arista bush-like, i.e. consisting of some ramuli or branches, which are also feather-like. Proboscis not developed, only palpi present. Sunda I., not yet recorded in Australia (see Keiser 1951) .... *Ramuliseta* Keiser (Lochmostylinae)

Arista simple; having only 1 stem. Proboscis usually small, but always very noticeable . . 2

2. Face with a high, flattened, facial carina (keel) as in *Rutilia*, *Amenia*, or *Prosena*, wholly separating the antennae one from another by a broad high wall (Fig. 1) .... *Maenomenus* Bezzi

Face with an acute, narrow keel, which is much lower than antennae; the latter may be contiguous, not separated by the keel, or face is represented only by a deep groove 3

3. Apical part of subcostal vein running into the costa obliquely, under a regular acute angle, its apex sometimes slightly weaker than the remainder of vein 4

Apical part of subcostal vein running into the costa under nearly a right angle, being thin, weak, and angulate (similar to Trypetidae) 11

4. Distinct epistomal area between antennal foveae and mouth-edge. 2 or 3 notopleural bristles, 1 or more bristles on sides of thorax 5

Face reaching the mouth-edge, forming a deep depression from antennae to mouth. Only 1 (posterior) notopleural bristle (or seldom 2), no bristles on sides of thorax (Plate 1, Fig. 7) .... *Facilina*, gen. nov.

5. Face without keel, represented only by a deep, nearly round groove which is not separated into two parts by a middle crest or keel. Third antennal joint broader than long, shorter than 2nd joint. At least 8 bristles on scutellum. Frons in male comparatively very narrow (Fig. 3) .... *Prodalmannia* Bezzi

Face always with a keel or at least with 2 elongated grooves forming the facial excavation. Third antennal joint always distinctly longer than 2nd, at apex usually acute (more rarely rounded). Scutellum with 4 bristles 6

6. Anal cell closed by a straight or nearly straight vein, its lower corner not attenuated. Jowls much higher or nearly as high as vertical diameter of eye. Frons extremely broad even in male, about half of width of head (Figs. 4, 5; Plate 1, Fig. 5; Plate 2, Fig. 11) .... *Frontalia* Malloch

Anal cell closed by a distinctly concave or angulate vein, therefore the lower part of cell attenuated. Jowls usually distinctly shorter than vertical diameter of eye. Frons broad, but less so than in *Frontalia* 7

7. Costa reaching only to the apex of vein r_{4+5} 8

Costa reaching to the apex of vein m_1 9

8. Vein r_{4+5} with some black bristles at base. Prosternal plate flat and bare (Fig. 6; Plate 2, Fig. 12) .... *Nicholsonia* Malloch

Vein r_{4+5} quite bare at base. Prosternal plate elevated and haired on sides (Figs. 7, 8) .... *Campylocera* Macquart

9. Body reddish yellow. Length of wing at least 11 mm 10

Body dark brown. Length of wing at most 8 mm. Claws in female bifurcated. Ovipositor extremely long and narrow, longer than remainder of abdomen. Mesopleural, pteropleural, sternopleural bristles always more than 1 (Plate 2, Figs. 13, 15, 16) .... *Osa*, gen. nov.

10. Scutellum only with 4 bristles, no hairs. Facial keel in profile slightly concave. Antennae long, 2nd and 3rd joints together distinctly longer than half of vertical diameter of eye (Plate 1, Fig. 1) .... *Adapsilia* Waga

Scutellum with more than 4 bristles and some little bristles and hairs. Facial carina (keel) in profile deeply concave. Antennae short, 2nd and 3rd joints together distinctly shorter than half vertical diameter of eye. Strong similarity to *Acropyrgota*, but form of apex of subcostalis is different, also the shape of 3rd antennal joint (Plate 2, Fig. 14) .... *Adapsona*, gen. nov.

11. Scutellum haired and with some bristles 12

Scutellum not haired, with 4–12 bristles 13

Scutellum bare, with only 2 bristles. Vein r_{2+3} with a stump, and before it forming a bow towards the costa .... *Commoniella*, gen. nov.

12. Notopleural bristles—1: 2 or 3. Ocelli present. Cheeks narrow (Fig. 12) .... *Neotoxura* Malloch
  Notopleural bristles—1: 1. Ocelli absent. Cheeks very broad (Fig. 13) .... *Acropyrgota* Hendel

13. First longitudinal vein (r_1) ending at or before level of crossvein *r-m*. Presutural bristle absent (Fig. 10, 11; Plate 1, Fig. 2) .... *Paratoxura*, gen. nov.
  Vein r_1 always ending distinctly beyond level of crossvein *r-m*. Presutural bristle present 14

14. No dorsocentral bristles. All the femora, in at least the male, armed with short stout bristles on the apical fourth or less of the anteroventral and posteroventral surfaces. Wings with narrow alternating hyaline and dark crossbands .... *Epice*, nom. nov. (=*Epicerina* Malloch, preocc.)
  One to 2 or more dorsocentrals always present. No similar armament of femora as mentioned above. Wings hyaline or with very numerous hyaline rounded spots on dark surface 15

15. Costa sharply broken at apex of subcostal vein. Four dorsocentral bristles (1 presutural, 3 postsutural) (Plate 1, Fig. 6) .... *Musgravena*, gen. nov.
  Costa complete, with at most 3 dorsocentral bristles 16

16. Wings with a net of dark spots (only *E. similatrix* has quite hyaline wings). Stigma (from the apex of subcostalis to the 1st radialis) usually with 2–3, at least 1, light round "windows" (in *E. similatrix* stigma nearly absent). If a net of spots is absent, wing pattern is very well developed. Wings long and broad. The acute facial keel usually noticeable in profile (Figs. 14–17) .... *Epicerella* Macquart
  Wings hyaline, or with two dark spots, or if the wing is examined on a black background, some more white spots can be seen on the surface, or the pattern is poorly developed, and the stigma never has round, light "windows". Facial keel deeply sunken, not visible in profile, except in *Austromyia* 17

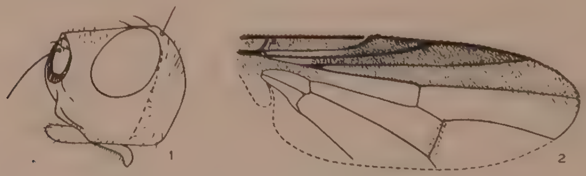
17. Wings hyaline or (if examined on a black background) some white spots are visible on the slightly greyish surface (Plate 1, Fig. 3) .... *Pyrgella*, gen. nov.
  Wings with only 2 well-developed black spots (Fig. 9) .... *Cardiocera* Macquart

Genus MAENOMENUS Bezzi

(Fig. 1)

Maenomenus Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 4.

Generotype *Maenomenus ensifer* Bezzi, 1929.



Figs. 1 and 2.—*Maenomenus ensifer* Bezzi: 1, head; 2, wing.

The author, knowing the variability and heterogeneity among the different genera of Pyrgotidae, cannot accept the view of Malloch (1929, p. 28) that *Maenomenus* is not a pyrgotid. The close relationship of *Maenomenus* to the typical

Pyrgotidae is quite evident and a few aberrant characters cannot camouflage the true pyrgotid affinities of this genus. Especially important is the structure of the ovipositor which is typical of the Pyrgotidae.

MAENOMENUS ENSIFER Bezzi

(Fig. 2)

Maenomenus ensifer Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 6.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, Canberra, 24.xi. 1954, 1♂; 2.xii.1954, 3♂♂, 1♀; 6.xii.1954, 1♂; 13.xii.1954, 1♂; 14.xii.1954, 1♂; 21.xii.1954, 2♂♂, 1♀; 24.xii.1954, 1♂; 30.xii.1954, 1♂, 1♀; 12.i.1955, 1♂; 27.i.1955, 1♂; 3.i.1955, 1♂; 7.i.1955, 1♂; 17.i.1955, 2♂♂, I.F.B. Common (all from light trap). NEW SOUTH WALES: Milson's Pt., 12.xii.1937, A. Musgrave, 1♂; Maroo Meadow, 6.xii.1926, B. Bertram, 1♂.

Type, male, from Manly, N.S.W., and allotype in the School of Public Health and Tropical Medicine, University of Sydney.

Genus PRODALMANNIA Bezzi

Prodalmannia Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 18.

Generotype *Prodalmannia variabilis* Bezzi, 1929.

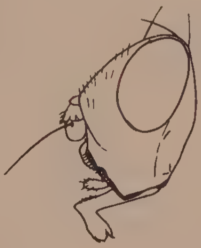


Fig. 3.—Head of *Prodalmannia variabilis* Bezzi.

Bezzi has given a thorough description of this genus and the author finds it necessary to give only some additional data.

PRODALMANNIA VARIABILIS Bezzi

Prodalmannia variabilis Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 19.

The author has examined only one male and finds it necessary to add some further remarks:

Hairy body, unusually long proboscis, eye very large in relation to the head (when viewed in profile) (Fig. 3), face very short, represented practically only by a deep excavation, anal cell acute at lower angle, the vein *r-m* situated at last third of discal cell, and the termination of subcostalis under an acute angle make this genus very easily recognizable. It is interesting to note that despite 8 years collecting by the author in the Canberra area, and at least 3 years of regular collecting by Mr. I. F. B. Common with light traps, no specimens were collected in the Canberra area, but this species is evidently abundant in the Sydney area.

Type and allotype in the School of Public Health and Tropical Medicine, University of Sydney.

Specimen examined.—NEW SOUTH WALES: Mosman, 25.xi.1923, Mackerras, 1♂.

Genus FACILINA, gen. nov.

Generotype *Facilina campbelli*, sp. nov.

Belongs to the group of genera with the subcostal vein running into costa at an acute angle. Distinguishable from other genera by many characters peculiar to this genus. Whole face from the base of antennae to mouth-edge is a long cavity without trace of a middle keel; antennal foveae absent because whole epistomal area is fused with them, forming a large concavity between antennae and mouth-edge. The peristomalia usually approach one another at end of antennal foveae, here nearly parallel, approaching only at mouth-edge. Epistomal area is sunk. Cheeks very narrow, nearly absent in profile. Palpi clavate, very short, as long as the fleshy proboscis. Jowls very large, about as high as long axis of eye, which is situated very obliquely. Occipital part developed very strongly in lower part.

Ocelli, ocellar tubercle, and ocellar bristles quite absent. On head only one pair of vertical bristles, all other bristles absent. Facets enlarged, larger in the disc. Antennae long, 3rd joint elongated, triangular, at apex subacute.

Thorax with very few bristles: only 1 posterior notopleural bristle, 2 postalar bristles on the extremities of postalar calli, 1 dorsocentral bristle (prescutellar), 4 scutellar bristles; scutellum haired. Sides of thorax without bristles. Legs long, narrow.

Wings hyaline. Anal cell closed by a slightly convex vein, vein r-m slightly beyond the middle of discal cell; vein m_1 in its 4 sections nearly straight. Costa reaching the apex of m_1. Apex of r_1 about at level of r-m. Abdomen long and narrow, with ovipositor at least as long as the remainder of body, similar to that in *Osa*.

KEY TO SPECIES OF THE GENUS FACILINA

1. Legs uniformly coloured, yellowish. Male unknown .... *F. commoni*, sp. nov., ♀
   Legs yellow, but with distinct black markings 2
2. Antennae brown. Anterior coxae dark. Frons uniformly yellow. Ovipositor very long, not broadening at apex. Anterior notopleural bristle very poorly developed or absent in both sexes .... *F. campbelli*, sp. nov., ♂, ♀
   Antennae black. Anterior coxae yellow. Frons yellow, with a large black ocellar spot. Ovipositor broadening at apex. Anterior notopleural bristle well developed. Male unknown .... *F. tertia*, sp. nov., ♀

FACILINA CAMPBELLI, sp. nov., ♂, ♀

Female.—Ground colour of body yellow, abdomen reddish yellow. Eyes dark, slightly purplish, transparent. Antennae and palpi dark brown, nearly black. Mouth-edge narrowly black in front. Frons and upper part of occiput with very short black hairs, other parts with microscopic light hairs. Second antennal joint as long as the 3rd, black-haired, arista shorter than the 2 apical joints combined. In profile the face is very strongly retreating.

Mesonotum with 4 not very well-developed narrow brownish stripes, the median extending from the anterior margin to level of wing bases, the lateral from the humeral callus to the dorsocentral bristle. Mesonotum with extremely short black hairs, sides of thorax nearly bare. Scutellum with black hairs, longer than on mesonotum and directed towards the mid line. Halteres yellow. Wings hyaline, slightly yellowish. Vein r_1 strongly ciliated, 5–6 short bristles on upperside at base of r_{4+5}.

Legs with very characteristic markings: (1) anterior coxae brown only on underside; (2) all femora yellow, but slightly darkened dorsally on apices; (3) tibiae dark, with a yellow spot in the middle; (4) metatarsi of all legs very long, longer than 4 following joints combined, yellow; (5) last joint of tarsi dark. No bristles on legs, hairs extremely short.

Abdomen very long, cylindrical, with very short black hairs; ovipositor very long, regularly narrowing towards apex and flattened from above in this area.

Length of body 7 mm (excluding ovipositor), of wing 7 mm.

Male.—Very similar to female. Anterior coxae are black only at apex, all metatarsi black, not yellow. Poorly developed anterior bristle on notopleurae shows that the male belongs to this species, in spite of the different localities.

Specimens examined.—VICTORIA: Mt. Difficult Range, Grampians, 2600 ft, 7.ii.1956, I.F.B. Common, 3♂♂. TASMANIA; Rupert Pt., 3 miles N. of Pieman R., 30.xii.1953, T. G. Campbell, 1♀.

Type, female, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

FACILINA COMMONI, sp. nov.,♀

(Plate 1, Fig. 7)

Closely related to *F. campbelli*, but easily distinguishable by its quite reddish legs without dark markings.

Ground colour of body reddish yellow, but palpi darkened and antennae also dark, yellowish only at articulation of 2nd and 3rd joints; on vertex a little black shining spot, but no ocellar triangle or tubercle. Eyes purple, with large facets. Vertex broader than in *campbelli*. Shape of head as in *campbelli*.

Face deeply sunken, but in epistomal area narrower than in *campbelli* and having a form transitional between that of the latter species and other pyrgotids.

Mesonotum red, shining. Chaetotaxy similar to that of *campbelli*, but with 2 notopleurals, and all bristles situated distinctly obliquely, whereas in *campbelli* these are placed almost perpendicularly. Wings, halteres, and legs as in *campbelli*, but legs without dark markings.

Abdomen narrow, slightly clavate, conopid-like, with long and strong ovipositor, flattened in the apical part, comparatively broader than in *campbelli* and slightly bilobate at apex.

Size as for *campbelli*.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 22.ix.1955, I.F.B. Common, 1 ♀ (type); 23.xi.1956, I.F.B. Common, 1 ♀ (both in light trap).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Facilina tertia, sp. nov., ♀

Closely related to *campbelli*, but separated easily by the characters mentioned in the key.

Ground colour of body reddish yellow, but antennae, eyes, and 1 rhomboid spot in ocellar area black. Vertex extremely broad, occupying at least half of head width.

Ocelli, ocellar triangle, and ocellar bristles absent; there are only a few hairs on the black ocellar spot. There are 2 weak pairs of external and internal (nearly decussate) bristles, other bristles on head practically absent. Antennae comparatively long, 3rd joint is 2·5 times as long as the 2nd one. Arista thin, long, shorter than antennae. Cheeks in profile extremely narrow, narrower than the 1st antennal joint. Jowls very high, their length is nearly equal to the greatest diameter of eye. Proboscis yellow, palpi black, both very short.

Mesonotum with 2 almost touching, parallel, short black stripes on anterior part. Chaetotaxy: humeral bristle hair-like, 2 very weak notopleural bristles, about equal, 2 bristles on postalar calli, 1 prescutellar dorsocentral bristle which is separated from the similar one on the other side by a very broad space. Bristles on pleurae hair-like, almost absent. Scutellum with 4 bristles, the apical pair decussate. Postscutellum yellow, but postnotum deep black, as well as spots above the mid and hind coxae and halteres. All femora yellow, with slightly blackened tips, all tibiae predominantly black, only at bases are they yellow; all metatarsi yellow, rest of tarsi blackened.

Wings hyaline, slightly yellowish. Crossvein *r-m* a little beyond the middle of discal cell. Anal cell closed by quite straight vein.

Abdomen brown at base, black in the middle part, and yellow on very long ovipositor. The basal part of ovipositor is triangular, short, laterally black, yellow in the mid part, then strongly compressed from sides, being represented by a narrow plate. This plate is depressed from above, thus forming a shovel-like plate. Ovipositor itself is about as long as the rest of abdomen or slightly longer. The first very long segment of abdomen laterally bearing some long black hairs.

Length of body 5·5 mm (excluding ovipositor, which is directed downwards), of wing 5·5 mm.

Specimen examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 30.iv.1957, I.F.B. Common, 1 ♀ (light trap).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Genus FRONTALIA Malloch

Frontalia Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 28.

Generotype *Frontalia genalis*, Malloch, 1929.

The description of four new species of the genus *Frontalia*, which was previously known only from a single species, *F. genalis*, makes it necessary to modify slightly the characteristics of the genus. It belongs to the group of genera which have a subcostalis terminating in the costa at an acute angle, the jowls very high, at least as large as vertical diameter of eye, frons very broad even in male (at least half of head width), anal cell closed with a nearly or quite straight vein, ocelli present or absent, postocellars present or absent, size under 10 mm, wings usually quite hyaline.

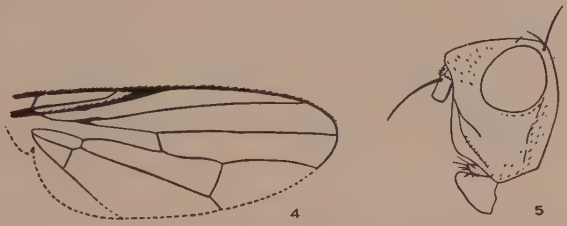
KEY TO SPECIES OF THE GENUS FRONTALIA

1.	Ocelli absent. Postocellars present	2
	Ocelli present. Postocellars absent	3
2.	Whole body yellow	*F. noctua*, sp. nov., ♂, ♀
	Abdomen brownish black	*F. genalis* Mall., ♂
3.	Abdomen yellow. At apex of wing a brownish spot	*F. montana*, sp. nov., ♂
	Abdomen black. Wing quite hyaline	4
4.	Legs deep black, with yellow tarsi. Mesonotum shortly haired	*F. bredboana*, sp. nov., ♂
	Legs brownish, with yellow tarsi. Mesonotum with long hairs	*F. tonnoiri*, sp. nov., ♂

FRONTALIA GENALIS Malloch

(Figs. 4, 5; Plate 1, Fig. 5)

Frontalia genalis Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 29.



Figs. 4 and 5.—*Frontalia genalis* Mall.: 4, wing; 5, head.

Mr. D. J. Lee has kindly provided the author with some additional data on the type:

"(1) There are no ocelli.

(2) Sternopleural bristles: one large and five small ones; of the smaller ones, four are in line with the large one close to the upper border of the sternopleuron, the fifth is below this line.

(3) The anterior two-thirds of the wing is suffused with yellowish colour. There is no obvious stigma but there is a small round darker yellow spot in the angle between costa and subcosta adjacent to the humeral veinlet. The subcosta and radius are closely adjacent, with no space for any spot between them.

(4) The femora are reddish brown, similar in colour to the thorax, darker at apices; the tibiae and tarsi are a lighter, rather more yellowish, brown."

Type from Glen Forest, Darling Range, W.A., in the School of Public Health and Tropical Medicine, University of Sydney.

FRONTALIA MONTANA, sp. nov., ♂

Whole body yellow. Eyes, very small ocellar triangle, middle stripe in mouth excavation, and hairs black. Proboscis, last joints of tarsi, and abdomen slightly darker than other parts. Frons extremely broad, occupying at least half of head width, with some microscopic hairs. Ocellar bristles absent. One pair of orbitals extremely weak. Postocellars absent. Two pairs of verticals, practically situated on occipital part; internal pair stronger, slightly convergent, external short, divergent. Cerebrale nude, sides of occiput with very sparse, short hairs.

Eyes in profile nearly round, their vertical diameter slightly shorter than the extremely high jowls. Cheeks broad, about as broad as half horizontal diameter of eye. Cheeks and jowls quite bare, only edges of peristomalia with microscopic yellowish hairs. Face extremely narrow, peristomalia strongly convergent, therefore the face at bottom as broad as distance between the bases of antennae.

Antennae short, only slightly longer than half vertical diameter of eye. Third joint very acute at apex, narrowed, only slightly longer than the 2nd. Arista yellow, slightly longer than antennae. Palpi short, not very broad; proboscis short, shorter than vertical diameter of eye. Head dull, only occiput shining.

Mesonotum shining, semipellucid, without markings. Only 4 prescutellar bristles: 2 acrostichals, 2 dorsocentrals. Presutural bristle absent. 1 mesopleural, 1 sternopleural, 1 pteropleural bristle. Legs comparatively short, with some bristles on upperside of front and hind femora.

Wings hyaline, with yellow veins and poorly developed dark marking at the apex of wing (distal to the apex of discal cell); probably absent in female wings. Vein m_1 quite straight in its discal cell portion. Vein *r-m* distinctly beyond the middle of discal cell. Vein r_{2+3} with a short veinlet directed downwards. Vein which closes the anal cell is nearly straight. Marginal cell (stigma) yellow. Vein m_1 in its discal part only slightly curved.

Abdomen short, broad, with very short black hairs.

Length of body 5 mm, of wing 4 mm.

Specimen examined.—NEW SOUTH WALES: Mt. Boppy, near Cobar, 25.xi.1949, S. J. Paramonov, 1 ♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

FRONTALIA TONNOIRI, sp. nov., ♂

Closely related and very similar to *montana*, but easily distinguishable by its dark brown legs and abdomen.

Third antennal joint and arista also darker brown, the latter with 2nd joint thickened. Ocellars present. Mesonotum with 4 well-developed very dark brown (nearly black) longitudinal stripes, the submedian pair of which extend from the anterior margin to the scutellum; another pair, sublateral, is shortened in the presutural area. Frons with 2 pairs of weak orbitals situated obliquely. Presutural bristle present. Bristles and hairs on mesonotum and sides of thorax distinctly longer than in *montana*, 1 sternopleural present, the remainder as in *montana*. Colour and venation of wing very similar, but the apical dark marking absent. Vein which closes anal cell quite straight.

Abdomen with hairs which are longer than in *montana*, and with very long lateral bristles (absent in *montana*).

Length of body 5 mm, of wing 4 mm.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 24.x.1930, A. L. Tonnoir, 2 ♂♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

FRONTALIA BREDBOANA, sp. nov., ♂
(Plate 2, Fig. 11)

Easily distinguishable from other species by the black colour of its thorax, abdomen, and legs (excluding tarsi).

Ground colour of head predominantly yellow or reddish yellow. Proboscis, palpi, ocellar triangle, 3rd antennal joint, and clypeus partly black; in some specimens there are also irregular black spots on occipital part. Two ocellar bristles present. Two orbitals situated obliquely. Inner verticals convergent, rather strong; outer verticals nearly absent, hair-like. Frons and occiput with very short, microscopic hairs. Third antennal joint short, as long as the 2nd, subacute. Jowls extremely high, distinctly greater than vertical diameter of eye. Peristomalia (face borders) not so convergent as in *montana* or *tonnoiri*.

Thorax deep black, with strong sheen, but humeral calli, scutellum, mesopleurae, and sides of mesonotum yellow. Hairs and bristles on thorax comparatively short and weak. Presutural bristle hair-like. One mesopleural, 1 pteropleural bristle, sternopleural absent. Legs short, deep black, tarsi yellow. Wings quite hyaline, with black veins and dark stigma. Venation as in other species. Vein r_1 as in *montana* and *tonnoiri*, short, at most on the same level as vein *r-m* (in *noctua* it is distinctly longer). Halteres dark.

Abdomen very broad, stout, shining, with very short, sparse hairs.

Length of body 5 mm, of wing 4 mm.

Specimens examined.—NEW SOUTH WALES: Canberra–Bredbo road, 23.x.1948, S. J. Paramonov, 11♂♂ (on flowers of low plants, during day).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

FRONTALIA NOCTUA, sp. nov., ♂, ♀

This species is somewhat aberrant in comparison with *montana*, *tonnoiri*, and *bredboana*. Body more elongate, abdomen also, nearer to that of *Maenomenus*. After more detailed study of the Australian Pyrgotidae it may be necessary to erect a new genus for it.

Whole body yellow, only eyes black. Face in profile very retreating, cheeks very narrow, less than one-third of horizontal diameter of eye. Proboscis extremely short, rudimentary, represented only by labella, palpi not noticeable. Ocelli, ocellar triangle, and ocellars quite absent. Only a pair of very weak verticals. Peristomalia strongly convergent.

Hairs on thorax very poorly represented, not numerous (it is possible to count them). Bristles weak. No presutural bristle, 2–3 mesopleural bristles, pteropleural extremely weak, sternopleural practically absent. Legs comparatively long, slender, without bristles. Wings hyaline, with yellowish veins. Vein r_1 distinctly beyond level of *r-m*. Vein *r-m* distinctly beyond the middle of discal cell. Apical part of first posterior cell broad, with straight, nearly parallel sides. Vein closing anal cell quite straight. Stigma (marginal cell) not very well marked, yellowish.

Abdomen very narrow, narrower than thorax, nearly bare, with some black hairs only on last tergite. Ovipositor of female longer than remainder of abdomen, conical, nearly transparent, very acute at apex.

Length of body 4–4·5 mm, of wing 4 mm.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 25.xi.1954–23.xii.1954, I.F.B. Common, 16 ♂♂, 10 ♀♀ (all specimens collected in light trap).

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Genus OSA, gen. nov.

Generotype *Osa commoni*, sp. nov.

Belongs to group in which the subcostalis, being weak at apex, runs into the costa at an acute angle. Ocelli absent. Ovipositor in females extremely long, usually much longer than the remainder of abdomen. All claws bifurcated in females only (a quite unusual character in this family). Hind tibiae of both sexes very thin in basal part, thinner than hind metatarsus (viewed in profile). Third antennal joint rounded or subacute at apex, never acute.

KEY TO SPECIES OF THE GENUS OSA

1. Females 2
Males 6
2. Ovipositor in apical part simple 3
Ovipositor in apical part bifurcated, flattened, appearing as a very thin plate 4
3. Ovipositor in apical part rounded, with short but rather numerous erect hairs. N.S.W. .. .. *O. commoni*, sp. nov., ♀
Ovipositor in apical part flattened, appearing as a thin plate. W.A. .... *O. bornemisszai*, sp. nov., ♀
4. Ovipositor with a distinct dorsal tubercle anterior to flattened apical portion, especially noticeable in profile. A.C.T. .... *O. sinclairae*, sp. nov., ♀
Ovipositor without such a tubercle 5
5. Two pairs of dorsocentral bristles. N.S.W. .... *O. simplex*, sp. nov., ♀
Three pairs of dorsocentral bristles. W.A. .... *O. westralica*, sp. nov., ♀
6. Wings quite hyaline. Legs reddish yellow, of same colour as the whole body. Larger species (8.5–9 mm). Hind tibiae with 2 black annuli (rings). Tas., N.S.W. .... *O. commoni*, sp. nov., ♂
Wings spotted, with at least 2–3 dark markings. Femora usually much darker than whole body, nearly black. Smaller species (7–7·5 mm). Hind tibiae without 2 black annuli, or, if present, conspicuous 7
7. Wings with 2–3 dark markings, but not spotted. Legs nearly of same colour as whole body 8
Wings distinctly spotted, especially in the apical part. Femora always much darker than the body, nearly black 9
8. Two pairs of dorsocentral bristles. N.S.W. .... *O. simplex*, sp. nov., ♂
Three pairs of dorsocentral bristles. W.A. .... *O. westralica*, sp. nov., ♂
9. Larger species. Wings strongly spotted. W.A. .... *O. bornemisszai*, sp. nov., ♂
Smaller species. Wings not very strongly spotted. N.S.W. .... *O. sinclairae*, sp. nov., ♂

OSA COMMONI, sp. nov., ♂, ♀
(Plate 2, Fig. 15)

Largest Australian species with completely hyaline wings.

Ground colour of body yellow, but with some whitish and (on legs) dark brown markings; most of body covered by greyish pollinosity, the body is therfore dull, even the scutellum.

Sides of frons light yellow, nearly whitish, middle part brown, antennal area and cheeks yellow. Two orbitals, very weak, 2 ocellars, directed forward, 2 divergent postocellars, 2 strong inner parallel verticals, directed backwards, 2 very weak outer verticals directed laterally. Sides of occiput whitish. Antennae rather long, the 2nd joint distinctly longer than the 3rd, the last nearly black, the former yellow, arista longer than antennae. Third antennal joint at apex rounded. Palpi and proboscis brown. Prosternal plates quite bare.

Chaetotaxy of thorax as in *O. simplex*. Halteres yellow. Wings hyaline, with brownish stigma. Vein *r-m* slightly beyond the middle of discal cell. Last section of vein m_1 at base strongly curved. Apices of all femora with narrow darkened rings. Tibiae dark, with the middle third yellow. The spur at apex on underside of mid tarsi very strong, black. Claws very short, normal (♂) or bidentate (♀). Bristles on underside of hind coxae stronger in female, but not forming a brush.

Abdomen in male with long, but not numerous, bristle-like black hairs on sides; in female sides and hind margins of tergites covered with strong and long black bristles. Ovipositor extremely long, distinctly longer than remainder of abdomen, very narrow, nearly straight, without any tubercles, shining, black at apex and with black erect hairs.

Length of body 8·5–9 mm, of wing 8 mm; length of ovipositor 6·5 mm.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 15.x.1954–7.xii.1954, I.F.B. Common, 8 ♂♂, 8 ♀♀ (all in light trap). NEW SOUTH WALES: Tumbarumba, 3.xii.1929, J. W. Evans, 1 ♂. TASMANIA: Lake St. Clair, 13.i.1937, G. and C. Davis, 1 ♂.

Type, male, from Canberra, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

OSA BORNEMISSZAI, sp. nov., ♂, ♀
(Plate 2, Fig. 16)

Closely related to *commoni*, but differs in having distinctly spotted wings.

Palpi yellow, not dark as in *commoni*. Postocellars very strongly divergent, lying in nearly opposite direction; in *commoni* much less divergent. Legs darker, but the dark and yellow tibial marks not showing so much contrast as in *commoni*. Ovipositor of female black, shining, transparent, only the middle part brownish; apical fourth strongly flattened (not round as in *commoni*), quite bare. Hind coxae in female with only short hairs and 1 bristle; in *commoni* at least 4–5 bristles. Prosternal plates in both sexes haired.

Length of body 7·5 mm (♂)–11 mm (♀) (with ovipositor), of wing 6–6·5 mm.

Specimens examined.—WESTERN AUSTRALIA: Crawley, 4.xii.1953–26.i.1954, G. F. Bornemissza, 3 ♂♂, 5 ♀♀.

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

OSA SIMPLEX, sp. nov., ♂, ♀

Closely related to *O. sinclairae*, but distinguishable in both sexes by its quite hyaline unspotted wings.

Body brownish, not yellow, partly darker, partly lighter. Frons very protruding, cheeks viewed from above nearly parallel, vertical. Ocelli, ocellar triangle, and ocellar bristles or hairs absent. One pair of rather strong, distinctly diverging orbitals. Frons and upper part of cheeks with microscopic, but not numerous, black hairs. Postocellars strongly diverging.

Inner verticals strong, very decussate, outer verticals very short, strongly diverging, directed almost laterally. Cerebrale (central part of occiput) nearly bare, the remainder with short black hairs. Cheeks in profile at least as broad as half horizontal diameter of eye. Jowls about three-quarters height of eye. Antennae very short, 2nd and 3rd antennal joints of nearly equal length, the last joint distinctly darker, acute at apex. Proboscis short, practically represented only by labellum; palpi as long as proboscis, flattened although narrow, with short black hairs. Epistomalia at narrowest point separated by distance as broad as apex of 2nd antennal joint. Jowls and lower part of cheeks quite bare.

Humeral calli yellow, distinctly lighter than reddish brown mesonotum. Hairs black, microscopic. Scutellum hairless. Chaetotaxy: 1 humeral, 2 notopleural, 1 presutural, 1 intra-alar, 2 postalar, 3 dorsocentral, 1 acrostichal (prescutellar) on each half of mesonotum. Scutellum with 4 bristles. Row of bristles on mesopleurae well developed, 1 strong pteropleural, 1 strong sternopleural. Thorax, in general, dull, only scutellum slightly shining. Mesonotum with 4 inconspicuous reddish brown longitudinal stripes. Halteres yellow. Wings hyaline, with yellowish stigma and similar spot around *r-m*. Vein *r-m* situated on the middle of discal cell. Last portion of m_1 strongly arched.

Legs poorly armed, only mid tibia with a strong spur on underside, some bristles also on the dorsal side of fore femora.

Abdomen very narrow, elongate, distinctly narrower than thorax, covered by short black hairs and long sparse bristles at lateral margin. Ovipositor of female about as long as abdomen itself. Basal half of ovipositor conical, yellow; apical half flattened, very thin, laminate, bifurcate, the middle part of bifurcation straight.

Length of body 7–7·5 mm (♀), of wing 5·5 mm, ♂ a little smaller.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 3.xii.1954–28.i.1955, I. F. B. Common, 3 ♂♂, 4 ♀♀ (all in light trap).

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

OSA WESTRALICA, sp. nov., ♂, ♀

Closely related to *simplex*, but easily distinguishable by its 3 pairs of dorsocentrals (in *simplex* only 1 pair), the situation of *r-m*, which is placed distinctly beyond the middle of discal cell (in *simplex* in the middle), and the presence of some very short black hairs on the place where the ocellar triangle is usually situated (in *simplex* the hairs are quite absent).

Size slightly larger than in *simplex*, the whole body more stout.

Length of body 8 mm, of wing 6·5 mm.

Specimens examined.—WESTERN AUSTRALIA: Borden, 16 miles S. of, 9.x.1951, I. F. B. Common, 1 ♂, 1 ♀.

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

OSA SINCLAIRAE, sp. nov., ♂, ♀
(Plate 2, Fig. 13)

Smallest species, with spotted wings, but the spots are very weak, being conspicuous only on a white background. Third antennal joint rounded at apex. Vein *r-m* originating beyond the middle of discal cell. Chaetotaxy as in *simplex*. Cheeks are narrower than half horizontal diameter of eye. Femora always darker than the body. Membrane of wing slightly greyish; against a white background they can be seen to possess rounded white spots; these are more conspicuous in some specimens than in others, and are always more evident on the apical part of the wing. Ovipositor of female with a very well-developed strong dorsal tubercle at end of conical part; the tubercle finger-like when viewed in profile. Bifurcation at apex of ovipositor not as deep as in *simplex*.

Length of body 5·5–6·5 mm (♀), of wing 4·5 mm, ♂ a little smaller.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 1.xi.1954–27.i.1955, I. F. B. Common, 74 ♂♂, 32 ♀♀ (all in light trap).

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra. It is the commonest species in Canberra, but was discovered only in 1954.

This species is named in honour of Miss P. J. Sinclair, to whom the author is very indebted for assistance in sorting the numerous insects collected in light traps.

Genus NICHOLSONIA Malloch
(Fig. 6)

Nicholsonia Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 31.

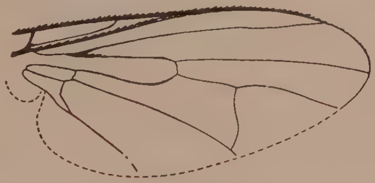


Fig. 6.—Wing of *Nicholsonia curvinervis* (Bezzi).

Generotype *Campylocera curvinervis* Bezzi, 1929.

This genus is readily distinguished from its allies by the characters noted in the foregoing key to genera.

In Malloch's key we find the following additional characters of this genus:

"Subcostal vein not rectangularly bent forward at apex; if the extreme apex is poorly developed, it lies close to apex of first vein and the latter is almost invariably swollen apically and more or less fused with costal vein (Text–fig. 13); if the first vein is distinct to apex, the second antennal segment is cleft and the mid coxal prong is present. Second antennal segment without a distinguishable longitudinal cleft at apex on upper side. Vertex not at all elevated. Fourth wing vein distinct to apex, the costal vein narrowed beyond apex of third vein but quite evident to apex of fourth; prosternal plate flat and bare; third wing vein setulose at base above."

NICHOLSONIA CURVINERVIS (Bezzi)

(Plate 2, Fig. 12)

Campylocera curvinervis Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 17.

The following characters are noteworthy: cheeks almost absent, extremely narrow in profile; jowls also narrow, maximally as broad as 1st antennal joint. Facial foveae occupying nearly whole face, the keel separating them nearly straight in profile, only slightly excavated. Scutellum haired. Crossvein *t-p* (closing discal cell) unusually large.

Specimens examined.—NEW SOUTH WALES: Allowrie, Killara, 23.ii.1929, 1 ♂; Mosman, 20 and 24.ii.1924, Mackerras, 2 ♀♀; Killara, 20.xii.1935, M. F. Day, 1 ♀. QUEENSLAND: Sarina, 14 miles SW. of, 8.v.1955, K. R. Norris, 1 ♂.

Type in the School of Public Health and Tropical Medicine, University of Sydney.

Genus CAMPYLOCERA Macquart

Campylocera Macquart, 1843, Dipt. Exot. **2** (3): 220.

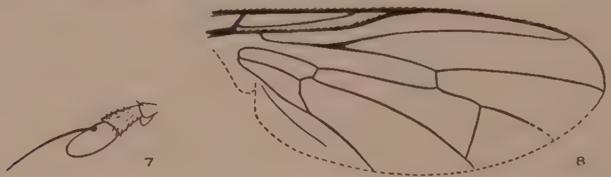
Generotype *Campylocera ferruginea* Macquart.

Subcostalis touching the costa at an acute regular angle. Face with acute keel. Anal cell closed by vein distinctly concave or angulated. Costa reaching only to the apex of r_{4+5}. Vein r_{4+5} quite bare at base. Closely related to *Nicholsonia*.

CAMPYLOCERA HYALIPENNIS Malloch

(Figs. 7, 8)

Campylocera hyalipennis Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 30, fig. 1.



Figs. 7 and 8.—*Campylocera hyalipennis* Mall.: 7, antenna; 8, wing.

This species is distinguished from *brevicornis* Hend., a New Guinea species, by the narrow cheeks and the lack of markings on the wings. The wing in the type specimen in certain lights and against a white background shows a very faint grey shade over the entire apex beyond the outer crossvein, and at level of the stigma there is a similar faint cloud, which, it is possible, in other specimens may be even more distinct.

Type from Cairns, N. Qld., in the United States National Museum.

CAMPYLOCERA BREVICORNIS Hendel

Campylocera brevicornis Hendel, 1908, Wien. ent. Ztg. **27**: 152.

This species is not yet recorded for Australia, but it is very probable that it will be found in the Cape York area.

This species can be distinguished from its related species by the strongly approximated transverse veins. The last section of the 4th longitudinal vein is 2·5 times as long as the penultimate, and the small transverse vein lies in the second third of the discal cell. *C. robusta* Wulp has less strongly approximating transverse veins, the 3rd antennal segment twice as long as the preceding one, and cylindrical palpi.

Type, female, from Astrolabe Bay, New Guinea, in the Hungarian National Museum.

Genus ADAPSILIA Waga

Adapsilia Waga, 1842, Ann. Soc. Ent. Fr. **1** (1): 279.

Generotype *Adapsilia coarctata* Waga.

Apical part of subcostalis touching the costa obliquely, under a regular acute angle. Face with an acute keel. Scutellum with 4 bristles. Anal cell closed by a vein distinctly concave or angulate. Costa reaching to the apex of vein m_1. Third antennal joint rounded at apex. Claws of female simple, not bifurcate.

KEY TO SPECIES OF THE GENUS ADAPSILIA

1. Wings absolutely hyaline .... *A. illingworthana* Bezzi, ♂
   Wings with markings 2
2. Wings with pre-apical narrow crossband from the costa throughout additional crossveinlet to m_1. New Guinea .... *A. aequalis* Malloch
   Wings with pre-apical longitudinal marking along the apex of vein r_{2+3}. N.S.W. .... *A. gratiosa*, sp. nov., ♂

ADAPSILIA ILLINGWORTHANA Bezzi

Adapsilia illingworthana Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 16.

A doubled 2nd notopleural bristle; extremely long 1st abdominal segment (in reality the 1st and 2nd segments are united), which is much longer than 2 following segments together; ocellar area practically on the occipital side; 4–5 nearly equally strong sternopleural bristles; very long antennae (and antennal grooves), which reach nearly to the epistoma; cheeks extremely broad, larger than horizontal diameter of eye; the form of vein r_{2+3}, which is in area of additional veinlet, angulate.

Specimen examined.—QUEENSLAND: Toowoomba, 26.i.1928, W. B. Barnard, 1 ♂.

Type, male, from Cairns, N. Qld., in the School of Public Health and Tropical Medicine, University of Sydney.

ADAPSILIA AEQUALIS Malloch

Adapsilia aequalis Malloch, 1939, Proc. Linn. Soc. N.S.W. **64**: 51.

The author has not seen this species, described from Papua.

Type in the British Museum.

ADAPSILIA GRATIOSA, sp. nov., ♂
(Plate 1, Fig. 1)

Whole body reddish yellow, but face carbon-black, proboscis brown.

Antennae and antennal foveae comparatively shorter than in *illingworthana*. Jowls high, only slightly shorter than vertical diameter of eye (in *illingworthana* they are about as high as half the diameter). Cheeks in profile comparatively narrow, less than a vertical half of the eye (in *illingworthana* they are about as broad as the diameter of eye). Vertex broader than one-third of head width, but not as broad as in *illingworthana*. Ocelli quite absent, ocellar tubercle absent, only a furrow in place of it. Practically only 1 pair of strong vertical black bristles; there are some reddish, very small, hair-like bristles which cannot be regarded as true bristles.

Black bristles on thorax as follows: 1 humeral, 2 notopleural (1 : 1), 1 supra-alar, 1 prescutellar dorsocentral, 2 postalar, 1 mesopleural, 1 sternopleural, 2 (very closely situated) pteropleural; scutellum bare, with 4 black bristles. Legs bristleless, nearly bare, claws long, the last joint of anterior tarsi distinctly broadened.

Wings hyaline, with black veins (in *illingworthana* they are reddish). Stigma slightly yellowish. At apex of vein r_{2+3} a distinct dark spot (stigma-like). The additional crossveinlet at its apex well developed.

Abdomen very long and narrow, the last tergite is the broadest one, the whole abdomen is nearly bare (in *illingworthana* the hairs are much longer).

Length of body 11 mm, of wing 11 mm.

Specimen examined.—NEW SOUTH WALES: Bega, 15 miles S. of, 3.xii.1956, I. F. B. Common, 1 ♂ (in light trap).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Genus ADAPSONA, gen. nov.

Generotype *Adapsona commoni*, sp. nov.

Belongs to the group of genera in which the subcosta joins the costa at an acute, very regular angle; its distal portion is regularly curved and entire. Face deeply sunken, with a keel. Anal cell closed by a vein either distinctly concave or somewhat interrupted, its lower part consequently rather attenuate. Costa extending to m_1. Wings hyaline, very long. Scutellum with a bristle and hairs. Body wholly reddish yellow. Close to *Acropyrgota*, but with form of subcostal apex and 3rd antennal joint different, the latter being distinctly rounded at its apex, neither attenuate nor acute. Claws simple in both sexes. Ocelli absent.

ADAPSONA COMMONI, sp. nov., ♂

Whole body reddish yellow, but 2 last joints of all tarsi black, abdomen usually mostly black or darkened, occasionally quite reddish yellow.

Head with proboscis, palpi, and antennae reddish yellow, but eyes deep black. Ocelli, ocellar tubercle, and ocellar bristles absent. Frons quite bare, with only a pair of divergent orbitals. Postocellars weak. Internal verticals comparatively strong, slightly converging; the external ones weak, strongly divergent. Occiput nearly bare, with some black microscopic hairs, the greater part with yellowish microscopic hairs. Cheek broad, about half horizontal diameter of eye; jowls slightly higher than half vertical diameter of eye.

Thorax shining, dorsally with black, ventrally with yellowish hairs and bristles. All bristles on thorax comparatively weak. Scutellum with about 10 marginal bristles and some separate on the disc. Prescutellar row consists of about 6 bristles. Legs not elongate, lacking bristles but with yellow hairs. Claws and last 2 joints of tarsi short and black. Only mid tibiae with 2 very short ventrodistal black spurs. Wings long, hyaline, slightly yellowish, with yellow veins. Vein *r-m* originating slightly beyond the middle of discal cell. Vein r_{4+5} distinctly curved downwards in apical part. Portion of vein m_1 before *r-m* straight, the apical part of vein m_1 distinctly curved. Stigma only slightly more intensely coloured than the rest of wing surface.

Abdomen yellow ventrally and anterodorsally, usually black on remainder of dorsal surface, occasionally wholly yellow, with few black hairs laterally.

Length of body 10 mm, of wing 11 mm.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, 28.xi.1954–21.xii.1954, I. F. B. Common, 5 ♂♂ (in light trap).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

ADAPSONA FULVA, sp. nov., ♀
(Plate 2, Fig. 14)

Closely related to *commoni*. Its quite yellow legs and its geographical distribution indicate that it is not a female of *commoni*.

Hairs on mesonotum and scutellum yellowish. Fourth joints of all tarsi broader than long (in *commoni* they are longer than broad). Ovipositor massive, compressed at the sides, at apex only slightly narrower than at base, a little longer than remainder of abdomen, with microscopic yellow hairs. The 1st and 2nd tergites (united) slightly longer than 4 following tergites combined.

Length of body 12·5 mm (excluding ovipositor), of wing 12 mm.

Specimen examined.—WESTERN AUSTRALIA: Brookton, 1 ♀, "41–1151".

Type in Western Australian Museum, Perth.

Genus CARDIOCERA Macquart

Cardiacera Macquart, 1847, Dipt. Exot. Suppl. 2. p. 92.

This genus was established by Macquart in 1847. By description Macquart has used the form *Cardiacera*, also by explanation of figures (p. 99) and by lettering on plate 6, but by description of species he had used a form *Cardiocera*. It seems that the last form is better grammatically and we propose to use the form *Cardiocera*.

All authors were in doubt of the systematic position of this genus, regarding it as belonging to Tephritidae of Macquart. Thanks to the kind assistance of Mr. J. E. Collin, who has the type species, *C. dispar* Macq. (see below), it is now stated definitely that the genus is a pyrgotid. However, in describing the type species Macquart was in error accepting both sexes as belonging to the same species; they belong to two different species and probably genera. Macquart's description is as follows:

> "Trompe et palpes assez épais. Face inclinée; épistome peu saillant; péristome allongé; dessous de la tête dilaté et convexe. Front saillant, à extrémité obtuse et concave, munie de soies courtes. Antennes inclinées, insérées sur la saillie du front; deuxième article conique, un peu allongé; troisième cordiforme; style nu. Oviducte court et carré; troisième segment de l'abdomen bordé postérieurement de quelques soies. Cuisses postérieures munies de quelques soies endessus. Ailes: première nervure transversale oblique; externo-médiaire arquée au-dela de la deuxième transversale.
>
> Nous formons ce nouveau genre pour une espèce de Tèphritides dont les caractères distinctifs sont nombreux et importants. Il est assez remarquable par la conformation de la tête et des antennes.
>
> Le nom générique fait allusion aux antennes dont le troisième article est cordiforme.
>
> L'espèce typique est de la Tasmanie."

CARDIOCERA DISPAR Macquart

(Fig. 9)

Cardiocera dispar Macquart, 1847, Dipt. Exot. Suppl. 2. p. 92, tab. 6, fig. 3.

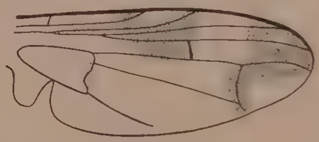


Fig. 9.—Wing of *Cardiocera dispar* Macq.

Macquart's description is as follows:

> "Ferruginea. Thorace vittis fuscis. Alis flavidis, albopunctatis ♂; maculis duabus fuscis.
>
> Long ♂ 3½ l., ♀ 4½ l. Palpes fauves. Face ferrugineuse. Front à bande brune ♂, testacée ♀; côtés blancs. Antennes ferrugineuses. Thorax à duvet ardoisé ♂; oviducte bordé postérieurement de noir ♀. Pieds ferrugineux. Ailes: les deux taches situées au bord extérieur; la première à la hauteur de la première nervure transversale; la deuxième à l'extrémité; les deux transversales distantes ♂, rapprochées ♀.
>
> De la Tasmanie. M. Bigot."

With regard to this species there is some confusion in Macquart's description: no details are given about the illustrations mentioned on p. 92 (i.e. tab. 6, fig. 3), but, on plate 6, illustrations are numbered 3, 3*a*, 3*b*, 3*c*. On p. 99, which gives an explanation of illustrations, is found "3. *Cardiacera dispar* (*a* caput, *b* antenna, *c* ala ♂)." If the illustrations are compared with the description it will be evident that they do not correspond, and that Macquart probably described two different species as different sexes of the same species.

First of all, fig. 3 shows an insect with wings slightly marked with colour, but in the Latin diagnosis we find "maculis, duabus fuscis", and in the French description "les deux taches situées au bord extérieur", but on fig. 3*c* the pattern is quite different from that on fig. 3. Thus the wing illustration fig. 3*c* corresponds to the description, but fig. 3 does not.

First conclusion: fig. 3 does not represent a specimen of *C. dispar*, but probably a closely related form. Second: the difference in pattern of wing and of venation ("les deux transversales distantes ♂, rapprochées ♀") indicates that the male probably does not belong to the female.

The author has consulted Dr. E. Séguy of Paris and Mr. J. E. Collin of London. Dr. Séguy has written that no type of *C. dispar* is present in the Paris Museum; the letter of Mr. Collin is quoted below:

"In reply to your letter of 29th June in regard to *Cardiacera dispar* Macq., though this was described by Macquart from specimens of both sexes in Bigot's Collection, there was only one specimen (a male) in this collection under that name when it was received by Mr. G. H. Verrall.

This specimen bears a MS label in Macquart's handwiritng "*Cardiacera dispar* ♂♀.ng., n.sp. Macq." which was gummed by Bigot onto another label to which he has added the locality as "Van Diemen", and "Macq. Dipt. Exot. nom;" I can give no information concerning the female. I have searched through the whole of Bigot's Trypetidae and Ortalidae for a specimen answering to this female, without any success.

The male appears to be a pyrgotid not unlike *Epicerella* in some respects. The prothoracic episternite, a vertical ridge in front of the anterior thoracic spiracle has the usual outstanding bristles, but at its lower end, on what I consider to be a separate small sclerite immediately above front coxae, there are a number of *down-curved* setae, apparently not usually present in some pyrgotids (e.g. *Adapsilia* and *Epicerella*). There are *no* ocelli, and the profile is very unlike that figured by Macquart. There is a long triangular flat area between the facial foveae and clypeus, while there is *no row* of prominent orbital setae as figured by Mcq., and the antennae are of normal shape (third joint with fairly straight upper margin and a parallel lower margin, with very rounded lower hind corner) *not* as figured by Mcq. It would appear therefore that Mcq's fig. "3", "3*a*" and "3*b*" were all drawn from the *female* of a different species, and as the generic name was an illusion to the shape of the antennae of this female, the missing female must be regarded as the type.

Some further characters which may help you to place the male are: prosternum with a row of fine hairs on each side, pteropleura with 2 stout bristles (upper one the longer). Only vein r_1 setose. Hind coxae with *numerous* curved *long* black bristles behind. (J. E. Collin)."

In his second letter Mr. J. E. Collin adds:

"(1) The first vein ends as in trypetids.

(2) The scutellum has four bristles and is otherwise bare.

(3) The costs ends in m_1."

The comparison of figs. 3 and 3*a* shows us that not only the pattern of wing but the venation (position of vein *r-m*) are different. If we compare the apices of subcostalis we can state that these figures belong not to two different species, but to different genera. The flattened form of ovipositor on fig. 3 is not a pyrgotid ovipositor. Fig. 3 illustrates probably a female of a tephritid.

It is evident that Macquart confused two quite different forms. The author thinks that a male must be selected as a representative of this species, because (1) it is mentioned before the female; (2) 2 large spots on wings being mentioned in diagnosis of species are present only in male, and illustrated on fig. 3*a*; (3) the position of vein *r-m* as being close to the middle of discal cell is also mentioned before the female character (the vein *r-m* is closer to the transversal vein *t-p*); (4) we have a male with a label of Macquart's hand ("n.sp.") the type.

The female illustrated on fig. 3 does not belong to *C. dispar*, and very probably is not a pyrgotid; if it will be found later it must have quite a new name, or have the name *Cardiacera*.

Additional requests to my collèagues Mr. J. E. Collin and Dr. Fritz van Emden (British Museum) has revealed that in the type of *Cardiocera dispar* (1) the apex of 1st longitudinal vein is situated far beyond the level of the vein *r-m*; (2) the 2nd notopleural bristle is single, not duplicate; (3) ocelli present (small) (Mr. Collin remarks: " ? absent (unless very close together and small)").

Genus PARATOXURA, gen. nov.

Generotype *Paratoxura norrisi*, sp. nov.

Closely related to *Neotoxura* Mall., but differing as follows: (1) simple, unduplicated 2nd notopleural bristle; (2) bare scutellum in the disc; (3) very short 1st longitudinal vein which does not reach the level of vein *r-m* (a character separating it from *Cardiocera*) or at most reaching it.

KEY TO SPECIES OF THE GENUS PARATOXURA

1. Wing hyaline, without markings .... *P. microps* (Hend.) ♂, ♀
Wing hyaline, but with 2 large dark markings along the costa at level of the base and apex of discal cell 2
2. Basal dark marking on wing without a "window" under pterostigma .... *P. norrisi*, sp. nov., ♂
Basal dark marking with a "window" under pterostigma .... *P. secreta*, nom. nov.

PARATOXURA NORRISI, sp. nov., ♂
(Plate 1, Fig. 2)

Ground colour of head yellowish. Eyes dark brown; from the lower part of eye towards the mouth excavation extends a dark, parallel-sided stripe; ocellar triangle very small, black, ocelli small but well developed; edges of face (peristomalia) are deeply black converging towards the facial hump and joining together in the facial excavation, which is deep, not long, and without a prominent keel. Cheeks in profile very broad, about as broad as half of horizontal diameter of eye, jowls also very high, about as high as three-quarters of vertical diameter of eye. Vertex very broad, occupying distinctly more than one-third of head width. Frons practically bare, only 2 very small orbital bristles present. Ocellars lacking. Postverticals very small, divergent. Both pairs of verticals situated on occipital part of head, very low, internal pair well developed, external small. Face, cheeks, and jowls nude. Epistomal area is longer than facial cave. Antennae short, reddish, with 3-segmented arista. Third antennal joint is straight on upperside, on underside rounded, at apex acute. Palpi yellow, narrow, parallel-sided, with some black bristles. Proboscis rather large, fleshy, brown.

Ground colour of thorax yellowish, but with some dark markings; mesonotum with 2 narrow sublateral black stripes, which run parallel, beginning from the level of 1st notopleural bristle to the internal bristle on postalar calli. Metanotum with a large, square, deeply black and shining marking in the centre (from the corners of scutellum to the bases of halteres). There is also a black spot in the centre of scutellum. There are 2 dark spots in front of posterior and mid coxae. Bristles on thorax short and weak. Two notopleurals, 2 pairs of prescutellar acrostichals, 1 pair of dorsocentrals. Scutellum with 4 bristles. Halteres yellow. Wings very similar to text-fig. 3 of Malloch (1929) but basal dark marking without a "window" under pterostigma; the apical marking is larger, covering the whole 2nd crossvein *t-p* on both sides and extends more in the 1st posterior cell; venation nearly the same. Legs yellowish, tarsi darker.

Abdomen brownish, especially above in apical part.

Length of body 6 mm, of wing 5·5 mm.

P. norrisi is distinguished easily by its dark abdomen and by the two dark submedian longitudinal stripes.

Specimen examined.—QUEENSLAND: Mt. Larcom, 18.iv.1955, Norris and Common, 1 ♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

PARATOXURA SECRETA, nom. nov.
(Fig. 10)

Toxura maculipennis Malloch (nec Macquart 1850), 1929, Proc. Linn. Soc. N.S.W. **54**: 24, text-fig. 3.

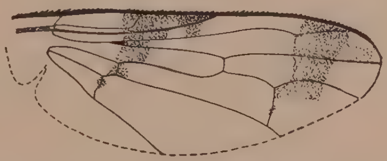


Fig. 10.—Wing of *Paratoxura secreta*, nom. nov.

Malloch (1929) has given a detailed diagnosis of the genus *Toxura*, and has described and illustrated a species which he regards as *T. maculipennis* Macq. The characters which he used and the figure of the wing (text-fig. 3) shows that he has interpreted wrongly the genus *Toxura* of Macquart. This genus does not belong to the Pyrgotidae, but is one of the trypetids. Describing this genus, Macquart put it after *Urophora* and before *Tephritis*, but the true systematic position is also quite evident from plate 26, figure 18, of Macquart (1850), where it can be seen that the fly illustrated is not a pyrgotid, it having a very long, narrow, parallel-sided ovipositor, whilst all pyrgotids have a robust, broad, inflated, highly specialized ovipositor. The venation is also different: the vein *r-m* in Macquart's species is situated about the middle of the discal cell, in Malloch's species it is distinctly beyond it; the discal cell in Macquart's species is not narrowed as in Malloch's species; the vein r_{4+5} is straight, without an additional veinlet, as in Malloch's species; the marking of the wing is similar, but not the same, as was stated by Malloch himself.

Therefore Malloch's species is not *T. maculipennis* Macq., but an unnamed pyrgotid, and the author proposes to name it *Paratoxura secreta*, nom. nov.

Malloch writes:

"The specimen differs from the species placed by me in the preceding genus (*Neotoxura*) in the following characters: Posterior notopleural bristle not duplicated, base of third wing vein bare above and below, face with a quite pronounced hump which is highest about middle of head in profile, the facial ridges convergent below, the angle situated at or above lower level of eyes, each orbit with one bristle above, postvertical lacking; first vein gradually approaching costa apically, its tip not beyond inner cross-vein; palpi strap-like; scutellum bare on disc." And adds: " . . . the markings of the wings are larger than in Macquart's figure and there is a small hyaline spot in outer apical angle of the preapical mark not shown by him (text-fig. 3)."

In the remarks to the species description he writes:

"This species would be difficult to identify by the use of the key given in the main part of this paper as the wings might as reasonably be considered banded as those of *variegata* and *robusta*, though the two prominent black marks on the costa do not pass much beyond the fourth vein on the field of the wing.

Locality, National Park, Sydney, N.S.W., 21.3.1925 (Health Dept.)."

The author has not found this specimen among the pyrgotids in the collection of the School of Public Health and Tropical Medicine, Sydney.

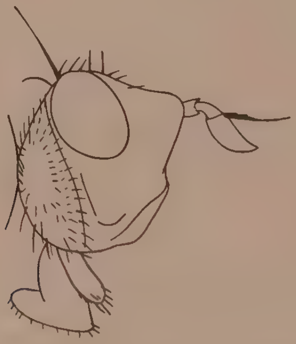


Fig. 11.—Head of *Paratoxura microps* (Hend.).

A male specimen collected by Mr. I. F. B. Common at Little Desert, 5 miles S. of Kiata, Vic., on 13.ii.1956, has a wing pattern exactly the same as in text-fig. 3 of Malloch.

Ground colour of body yellow but the head, lateral part of mesonotum and of the thorax ivory white. Metanotum, a central spot on scutellum, ocellar triangle, 2 fine epistomal lines, merging to form a facial keel-line, and an elongated spot under the eye toward the mouth cavity all dark brown. Antennae very short. Jowls very high, only slightly shorter than the vertical diameter of the eye. Ocellar triangle small, but well developed, 3 ocelli. Only 1 pair of quite microscopical bristles. On mesonotum only 2 notopleural bristles, 2 on postalar calli (both extremely small), 1 very small dorsocentral (prescutellar), and 1 acrostichal (also very small).

Legs with very weak bristles. Wings hyaline, with 2 very well-developed dark markings. Abdomen nearly bare, last tergite darkened.

Length of body 7·5 mm, of wing 6·5 mm.

Paratoxura microps (Hendel)

(Fig. 11)

Toxura microps Hendel, 1923, Arch. Naturgesch. A **11**: 115, fig. 15.

Hendel described this species from two (♂, ♀) specimens from Sydney and Moreton Bay, N.S.W., which are preserved in the British Museum.

Dr. Fritz van Emden has kindly informed the author that the type of this species (1) has the apex of 1st longitudinal vein slightly basad to level of *r-m*; (2) 2nd notopleural bristle is single; (3) ocelli absent.

Genus NEOTOXURA Malloch

Neotoxura Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 23.

Generotype *Toxura discoidalis* Bezzi, 1929.

Key to Species of the Genus Neotoxura

1. Wings wholly yellowish (♀), or with dark apical marking (♂). Apical half of palpi (♂) or whole palpi (♀) carbon-black .... *N. longipalpis* (Hend.), ♂, ♀
Wings not yellowish, with some distinct and indistinct dark markings. Palpi yellow 2
2. Wings not banded, with fuscous spots only. Inner crossvein broadly margined with fuscous 3
Wings with 2 dark bands, not interrupted by hyaline spots 4
3. Two pairs of ocellars. Postverticals present, crossed. Male unknown .... *N. discoidalis* (Bezzi), ♀
One pair of ocellars. Postverticals absent .... *N. neglecta* (D. E. Hardy), ♂, ♀
4. Postverticals lacking. Third antennal segment reddish yellow. Mesonotum pale brown. Intermediate pair of scutellar bristles sometimes wanting ... *N. variegata* (Hend.), ♂, ♀
Postverticals lacking (refer to original description of Hendel) .... *N. angustifrons* (Hend.), ♀
Postverticals present. Third antennal segment black or dark brown. Mesonotum largely black or dark brown. Scutellum with 6 strong bristles .... *N. robusta* (Bezzi), ♂

Neotoxura discoidalis (Bezzi)

(Fig. 12)

Toxura discoidalis Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 9.

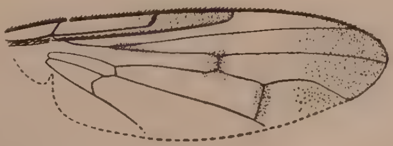


Fig. 12.—Wing of *Neotoxura discoidalis* (Bezzi).

The author has not studied the type nor seen additional material of this species.

Type, female, from Milson I., N.S.W., in the School of Public Health and Tropical Medicine, University of Sydney.

Neotoxura robusta (Bezzi)

Toxura robusta Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 8.

The author can add the following details: facial carina in profile nearly straight, protruding in comparison with cheeks. Face viewed from front very broad, parallel-sided, about three times as broad as one cheek. Third antennal joint broadly rounded, large. Arista long, much longer than antennae. Two orbitals. Jowls about as high as a half vertical diameter of eye. Occiput in its upper part nearly bare, with only a row of postocular short bristles. Ocelli very small but distinct. This species is larger and darker than *N. variegata*, but very closely related to it.

Type, male, from Warburton, Vic., in the School of Public Health and Tropical Medicine, University of Sydney.

NEOTOXURA VARIEGATA (Hendel), ♂, ♀

Toxura variegata Hendel, 1908, Wien. ent. Ztg. **27**: 148.

The author has not seen this species.

Type, male, from northern Australia, in the Vienna Museum.

NEOTOXURA LONGIPALPIS (Hendel), ♂, ♀

Toxura longipalpis Hendel, 1908, Wien. ent. Ztg. **27**: 147.

The author has not seen this species.

Type, female, from Sydney, in the Vienna Museum.

NEOTOXURA ANGUSTIFRONS (Hendel)

Toxura angustifrons Hendel, 1913, Arch. Naturgesch. A **11**: 116.

Dr. Fritz van Emden has kindly informed the author that the type of this species (contrary to the supposition of Malloch) has a duplicated 2nd notopleural bristle, and therefore it must be placed in the genus *Neotoxura*. In regard to the presence of hairs on scutellum the author has no data. Apex of 1st longitudinal vein in the type lies conspicuously beyond the level of the vein *r-m*, and ocelli are absent.

Type, female, from Burpengary, S. Qld., in the British Museum.

NEOTOXURA NEGLECTA (D. E. Hardy)

Austromyia neglecta D. E. Hardy, 1954, Proc. Hawaiian Ent. Soc. **15** (2): 327–30, figs, a–f (=*Neotoxura discoidalis* (Bezzi). D. E. Hardy, 1957, Proc. Hawaiian Ent. Soc. **16** (2): 259–60).

The species was described by Hardy (1954) as belonging to a new genus—*Austromyia* (Tephritidae); in 1957 he identified it as *Neotoxura discoidalis*. The author had some doubts about this identification and asked Mr. D. K. McAlpine, Australian Museum, Sydney, to compare the types of *discoidalis* and *neglecta*. The author was kindly informed that Mr. McAlpine regards the types as belonging to the two different species, the main difference being in the following characters: in *discoidalis* length of body 10 mm, of wing 9·5 mm; in *neglecta* length of body, including ovipositor of female to the down-curved portion 6·8 7·2 mm, of wing 7·5–8·0 mm; in *discoidalis*: 2 pairs of ocellars; postverticals present, crossed; 6 subequal scutellars; in *neglecta*: 1 pair of ocellars; postverticals absent: 4 scutellars, or if additional pair present it is much smaller.

Type in the Australian Museum. Type locality New South Wales.

Genus ACROPYRGOTA Hendel

Acropyrgota Hendel, 1913, Arch. Naturgesch. A **11**: 111.

Generotype *Acropyrgota flavescens* Hendel.

The genus is fully described by Hendel (1913). The author has not seen any members of this genus and cannot add any further data to Hendel's description.

ACROPYRGOTA FLAVESCENS Hendel

(Fig. 13)

Acropyrgota flavescens Hendel, 1913, Arch. Naturgesch. A **11**: 112, fig. 12.

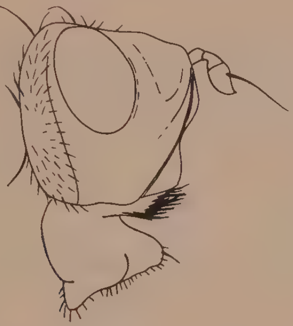


Fig. 13.—Head of *Acropyrgota flavescens* Hend.

Hendel has forgotten to give the locality of this species. Bezzi gives the type locality as "Australia". It is probable that Bezzi received his information directly by correspondence with Hendel. Bezzi includes in this genus a second species—*A. cribripennis*, but Malloch has transferred it, evidently with justification, to the genus *Epicerella*.

Genus EPICE, nom. nov.

Epicerina Malloch, 1939, Proc. Linn. Soc. N.S.W. **64**: 52.

Malloch (1939) described a new genus under the name *Epicerina*, but this name is preoccupied by *Epicerina* Macquart (1850, p. 97). The author proposes to replace the homonym by a new name—*Epice*, nom. nov.

This genus is very similar to *Epicerella* Macq., but differs in having all the femora, in at least the male, armed with short stout bristles on the apical fourth or less of the anteroventral and posteroventral surfaces, in having no dorsocentral bristles, 1 or more hind-marginal mesopleural bristles, 1 sternopleural, and 1 pteropleural bristle. For other characters see the description of the generotype, *E. setifemur* (Mall.).

EPICE SETIFEMUR (Malloch)

Epicerina setifemur Malloch, 1939, Proc. Linn. Soc. N.S.W. **64**: 52, fig. 2 (*Epicerina* preocc.).

Type, male, from Papua, in the British Museum.

Genus PYRGELLA, gen. nov.

Generotype *Pyrgella calabyana*, sp. nov.

Belongs to that group of genera having the subcostalis at apex angulate at a right angle. Scutellum not haired. First longitudinal vein r_1 ending noticeably beyond the level of vein *r-m*. Presutural bristle present. One pair of dorsocentral bristles (prescutellar) always present. Costa not broken at apex of subcostal vein. Ocelli absent. Face deeply sunken, facial keel not visible in profile. Wings hyaline, with very well-marked stigma; additional veinlet at r_{2+3} always present. Bristles on body poorly developed.

PYRGELLA CALABYANA, sp. nov., ♀

Ground colour of body black, but sides of frons, cheeks, jowls, and lower part of occiput yellow; humeral calli, a narrow short median longitudinal zone in front of scutellum, and 2 lateral zones from sutura to the sides of scutellum, and these sides also yellow. Cheeks in profile narrow, narrower than 3rd antennal joint, jowls extremely large, as high as vertical diameter of eye. Proboscis and palpi short, both these and epistomal area black. Face very short, deeply sunken, facial keel not noticeable in profile. Antennae very short, mostly represented by the apical joint which is rounded at apex; arista short, as long as antennae. Median half of frons nearly parallel-sided, dark brown. Ocelli, ocellar tubercle, and ocellar bristles absent. Only a pair of very short and divergent orbitals. Postocellars very short. Inner verticals converging, comparatively short and weak, but distinctly stronger than outer verticals, which are strongly divergent. Upper part of occiput bare, lower part with microscopic hairs, but these not numerous.

Mesonotum with extremely short, microscopic black hairs. Chaetotaxy usual, but only 1 pair of dorsocentrals and no acrostichals. One strong mesopleural, pteropleural, and sternopleural bristle. Prosternal plates haired. Propleurae with very long and dense black hairs. Legs black, only tarsi appearing slightly yellow due to their being covered with microscopic yellow hairs. Claws simple but long, longer than last tarsal joint. Pulvilli yellow. No strong bristles on the legs. Halteres yellow.

Wings hyaline, with black veins and black stigma. Vein r_{2+3} with a short additional veinlet downwards. Vein *r-m* slightly beyond the middle of discal cell. Discal cell narrow, its apical vein (*t-p*) nearly as long as the 1st posterior cell at its level.

Abdomen (with ovipositor) not very long, broad, flattened from above. Ovipositor at base broad, but at apex comparatively acute, distinctly flattened from above and below, shining, covered with rather dense, erect, black hairs.

Length of body 9·5 mm, of wing 9·5 mm.

Specimen examined.—WESTERN AUSTRALIA: Magooinya Rock, 4 miles WSW. of Balladonia H.S., 10.xii.1953, J. H. Calaby, 1 ♀.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

PYRGELLA CARNEI, sp. nov., ♂, ♀
(Plate 1, Fig. 3)

Closely related to *calabyana* but smaller; the female has a much shorter ovipositor.

Ovipositor is slightly shorter than the remainder of abdomen (in *calabyana* distinctly longer), it is regularly attenuated towards the apex and curved strongly downwards (in *calabyana* it is nearly straight, with at least the apical third thin, parallel-sided); hairs covering ovipositor more dense than in *calabyana*.

Length of body 6·5–9 mm, of wing 6·5–8·5 mm.

The male of *calabyana* is unknown, therefore it is not possible to compare it with the male of this species.

Normally all specimens have a very well-marked stigma, which is uniformly black or dark brown, but in some specimens there is one yellow spot in the middle of stigma. If examined on black surface, most specimens show some whitish spots on the greyish surface of wing, but on a white background wings seem to be quite hyaline.

The type has the colour of body browner than the whole series of 33 specimens collected by Mr. I. F. B. Common; probably the darker colour is the normal one, because all of the 33 specimens are freshly emerged and uniform in regard to the colour.

Specimens examined.—VICTORIA: Stratford, near Bairnsdale, 9.xi.1950, P. B. Carne, 1 ♂ (type); Little Desert, 5 miles S. of Kiata, 15.ii.1956, I. F. B. Common, 30 ♂♂, 1 ♀ (all in light trap); Jeparit, 5 miles W. of, 4.ii.1956, I. F. B. Common, 2 ♀♀. NEW SOUTH WALES: Shoalhaven R., near Braidwood, 14.iii.1956, S. J. Paramonov, 1 ♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Genus MUSGRAVENA, gen. nov.

Closely related to *Epicerella*, but a break in the costa (deep incision) at the apex of the subcostalis, hyaline wings, and extremely strange form of genitalia separate it very easily from *Epicerella*. Bristles on body very strong and long. Four pairs of dorsocentrals (one presutural).

Generotype *Musgravena anthonyi*, sp. nov.

The author dedicates this genus and species to Mr. Anthony Musgrave, Australian Museum, Sydney, to whom he is greatly indebted for assistance, especially on Australian bibliographical matters.

MUSGRAVENA ANTHONYI, sp. nov.
(Plate 1, Fig. 6)

Ground colour of body reddish yellow, but that of abdomen nearly black.

Head of *Epicerella* type, with strongly developed high facial keel, deep and long antennal grooves, and very protruding frons. Proboscis short, yellow; palpi about as long as proboscis, broad, flattened, black, with black hairs. Cheeks broad, about half as wide as half horizontal diameter of eye, with a dark spot between eye and base of antennae. Jowls high, about three-quarters of vertical diameter of eye. Facets of eye large. Facial keel in profile protruding, very acute. Antennae comparatively long. Third antennal joint subacute at apex, distinctly pointed. Frons mostly brown but sides much lighter, yellowish. Two strong, long, divergent orbitals present, situated on 2 narrow obliquely situated plates, as in some acalyptrates. Frons and upper part of cheeks with some short black hairs. Frons strongly protruding, with cheeks nearly parallel. Postocellars comparatively weak, parallel. Both pairs of verticals strong, the inner pair slightly convergent at its apices, the outer strongly divergent. Cerebrale extremely broad, bare. Occiput greyish pollinose; sides of occiput with some short black hairs, lower part near mouth cavity on each side with 1 moderately strong bristle. Arista very long, about 1·5 times as long as antennae: 3rd antennal joint distinctly darker than 2nd.

Mesonotum greyish pollinose, with 2 narrow, close, longitudinal stripes, and 2 sublateral brownish stripes.

Chaetotaxy: 1 humeral, 2 notopleurals, 1 presutural, 1 intra-alar, 2 postalars, 4 dorsocentrals (1 of them presutural, 1 postsutural very close to sutura), 1 acrostichal (prescutellar), 2 scutellars, 1 sternopleural, 1 pteropleural, 5 mesopleurals. All bristles strong and long.

Legs moderately long, claws long, yellow, black at apices; pulvilli yellow. Coxae and both sides of all femora with some strong bristles. Halteres yellow.

Wings long, rather broad, hyaline, but slightly greyish. Costa with a distinct incision at apex of subcostalis. Vein *r-m* originating slightly beyond middle of discal cell. Last section of m_1 strongly curved, but section before *r-m* nearly straight. Apical vein of discal cell long. Stigma practically absent. Prosternal plates bare, but at sides with bristles.

Abdomen narrower than thorax. Five tergites with very strong bristles, but central part bristleless.

Genitalia extremely strange: large, peculiar, with forceps as in male pyrgotids, but these forceps, contrary to male, are large. In pyrgotid males, in addition to a long basal abdominal segment (consisting of 2 united segments) there are 3 well-developed segments and genitalia; in *Musgravena*, besides the basal segment there are 4 well-developed segments, giving grounds for thinking that we are dealing with a female specimen (all female specimens of pyrgotid genera have 4 segments). The author therefore regards the strange structure as an ovipositor. Its length is about equal to the 4 last segments combined. The basal part is carbon-black, shining, convex, with very numerous long bristles and slightly decussate hairs, at the apex there are 2 claspers, overlapping one another and forming a ring, they are brown, directed dorsally, bare, also shining.

Length of body 11 mm, of wing 10 mm.

Specimen examined.- VICTORIA: Little Desert, 9 miles S. of Kiata, Oct. 1948, A. Musgrave, 1♀.

Type in the Australian Museum, Sydney.

Genus EPICERELLA Macquart

Epicerella Macquart, 1850, Dipt. Exot. Suppl. 4. p. 293.

Generotype *Epicerella guttipennis* Macquart, 1850.

Subcostal vein at apex forming nearly a right angle and weakened (similar to Trypetidae). Scutellum bare, with 4–12 bristles (usually 4). Presutural bristle generally present. Wings always spotted. Ocelli usually present or very small, reduced. Third antennal joint usually acute at apex, or only upper angle of it acute or (rarely) rounded. Facial carina usually very well developed, but in some species very low, nearly absent. The genus is rich in species, and variable, but there are no grounds for its subdivision, because all the species groups include forms with transient characters, and splitting of the genus could be both unnatural and impracticable.

Twenty-seven species are known from Australia, but the real number is doubtlessly much higher; there is very little material from Western Australia and the Northern Territory, a few odd specimens from these regions all belong to species here described as new.

Life histories of the species are associated with some lamellicorn beetles, but the collected data are not yet adequate for conclusions to be published.

KEY TO SPECIES OF THE GENUS EPICERELLA

1. Hind margin of scutellum with 8, 10, or 12 bristles 2

Hind margin of scutellum always with 4 bristles 4*a*

2. Large species (length of wing at least 15 mm), with very dark, spotted wings. Underside of hind femora with at least 10 bristles. Stigma (between the apices of subcostalis and vein r_1) dark, with a single white spot. W.A. .... *E. punctulata* Hend., ♂, ♀

Smaller species, Stigma with more than 1 white spot. If underside of hind femora with bristles, these very weak and not numerous 3

3. Legs nearly black, as in *E. punctulata*, but hind femora quite bristleless. Ovipositor of female only as long as remainder of body (in *E. punctulata* it is longer). Male unknown. S.A. .... *E. inermis*, sp. nov., ♀

Legs yellow, reddish yellow, or brownish, never nearly black 4

4. Ovipositor very long, narrow, at base only half as broad as long. Male unknown. W.A. .... *E. norsemanica*, sp. nov., ♀

Ovipositor comparatively very broad and short, at base as broad as two-thirds of length. S.A. .... *E. inermis*, sp. nov. (light variety).

Ovipositor much shorter than the remainder of abdomen. N.S.W., S.A. .... *E. cribripennis* (Bezzi), ♂, ♀

4*a*. Eyes distinctly haired. Vic. .... *E. pilosocula*, sp. nov., ♂

Eyes nude 5

5. All bristles more or less reddish, not black; halteres also reddish. Mesonotum with 2 sublateral very well-developed dark stripes, extending from anterior margin to lateral corners of scutellum. W.A. .... *E. bella*, sp. nov., ♂, ♀

All bristles on body black. Striping of mesonotum of another type 6

6. Pterostigma with only 1 hyaline spot in the middle; 2nd vein without a stump. Tas. .... *E. guttipennis* Macq., ♂

Pterostigma always with more than 1 hyaline spot, or destitute of hyaline spots, or the spot is not in the middle but at base 7

7. Wings more banded than spotted, pterostigma fuscous, always destitute of hyaline spots. Second vein without stump 8

Wings usually with numerous hyaline spots; pterostigma with 2–3 spots, or with a spot at base. Second vein usually with a stump 9*a*

Wings hyaline 9

8. Two pairs of dorsocentrals. Wings with an extensive dark pattern, forming distinct faciae 8*a*

Four pairs of dorsocentrals. Wings not fasciate, with more reduced dark pattern. N.S.W. .... *E. setosa* Bezzi, ♀*

*Compare also with *E. triangularis* Mall.

8*a*. Ocelli absent. A species with a most-developed dark pattern of wing. Not only the 2nd crossvein, but also m_2 with distinct brown spots. Vic. .... *E. noctua*, sp. nov., ♂

Ocelli present. A species with not so well-developed wing pattern, the middle of discal cell is hyaline. N.S.W. .... *E. plagiata* Bezzi, ♂ *

9. Five pairs of dorsocentrals (1 presutural); 1 upper orbital. N.S.W. *E. rava*, sp. nov., ♀

Three pairs of dorsocentrals; 1 upper orbital (and another quite microscopic). N.S.W. .... *E. simulatrix*, sp. nov., ♂, ♀

9*a*. Mesonotum with a pair of dorsocentrals, and another pair of acrostichal bristles, which form a transverse row of bristles in front of scutellum, or only with 2 dorsocentral bristles, or with 2 dorsocentrals and 2 acrostichals which do not form a straight row of bristles ..10

Mesonotum with more dorsocentral bristles 15

Mesonotum with only one pair of dorsocentrals, no acrostichals. N.S.W. .... *E. barringtoni*, sp. nov., ♂, ♀

10. Stigma uniformly yellow, without hyaline round spots 11

Stigma at least with 1 round hyaline spot. Discal cell always with some round hyaline spots 12

11. Only 2 dorsocentrals, but far ahead of 2 acrostichals. Third joint of antennae very long and acute. No postocellars. N.S.W. .... *E. acuticornis*, sp. nov., ♂, ♀

Two dorsocentrals and 2 acrostichals forming a prescutellar row of bristles. Third joint of antennae short, rounded at apex. Postocellars present. N.S.W. *E. montana*, sp. nov., ♂

12. Ocelli lacking. Female unknown. N. Qld. .... *E. multipunctata* Mall., ♂†

Ocelli present 13

13. Wings spotted, but not regularly so; a bifurcation of r_{2+3} and r_{4+5}; at apices of both basal cells there are very dark spots, much darker than the other surface. Hind coxa and trochanter of female with short but extremely dense brush of black bristles. Two pairs of orbitals in both sexes. N.S.W. .... *E. miliacea* Hend., ♂, ♀

Wings very regularly spotted, but without spots which are much darker than the other surface. Only 1 pair of orbitals. Hind coxa and trochanter with dense and long, or not very dense bristles; these never forming a brush 14

14. Length of wing 8 mm. Male unknown. N.S.W. .... *E. uniforma*, sp. nov., ♀

Length of wing 11 mm. Male unknown. Tas. .... *E. campbelli*, sp. nov., ♀

15. No hyaline spots in the apical fuscous portion of wings between 2nd vein and the costa, and only a hyaline streak in it on apical section of submarginal cell; face entirely yellow; ocellar triangle deep black, shining, the ocelli entirely lacking in type (♂). Female unknown. Qld. .... *E. triangularis* Mall., ♂

One or more hyaline spots in the marginal cell; face partly dark brown or black (except in *strumosa*); ocelli always present, sometimes small 16

16. Vein m_1 under *r-m* distinctly angulated, therefore the basal part of discal cell irregularly narrowed. Head and mesonotum dark brown. Female unknown. N.S.W. .... *E. nigrescens*, sp. nov., ♂†

Vein m_1 under *r-m* nearly straight. Discal cell regularly broadened towards the apex. Head and mesonotum yellow or brownish, never dark brown 17

17. Three pairs of dorsocentrals, the anterior very close to the suture. Wings uniformly spotted, without darker spots along costa. One orbital bristle .... *E. minor* Bezzi, ♂, ♀

Similar to *minor*, but length of body 10 mm, of wing 9 mm (not 6 mm). Fore femur in male as in *maculipennis*, with some well-developed bristles on basal half of posterior and apical half of posterodorsal surface. The female is uncomparable with the female of *minor* because the latter not known with certainty. N.S.W. .... *E. imitatrix*, sp. nov., ♂, ♀

Two pairs of dorsocentrals; if 3, the anterior pair not very close to suture. Wings usually with very well-marked darker spots along the costa 18

*Compare also with *E. triangularis* Mall.

†Compare with *E. armipes*, sp. nov.

18. On outer side of anterior femora there are some quite distinct bristles, 2 strong bristles also present at apex of outer side of hind femora. Occiput with a strong bristle on each side of ventral part as strong and usually stronger than those of propleura .... *E. maculipennis* Bezzi, ♂, ♀

No bristles on anterior and hind femora. Occiput without bristle on each side of ventral part, or if present, always much shorter than those on propleura 19

19. Face without black central stripe. Frons of male only slightly larger than one-third of head width .... *E. strumosa* Bezzi, ♂, ♀

Face with black central stripe. Frons of male distinctly larger than one-third of head width, occupying about half of head width .... *E. latifrons*, sp. nov., ♂

EPICERELLA PUNCTULATA Hendel, ♀, ♂

(Plate 1, Fig. 8)

Epicerella punctulata Hendel, 1913, Arch. Naturgesch. A **11**: 114, fig. 14.

Male (hitherto not recorded).— Very similar to the female. As in female only 2 lateral ocelli noticeable, the 1st ocellus nearly absent. Two rather strong and divergent postocellars in both sexes. Only 1 pair of orbitals directed backwards and outwards. Third antennal joint in both sexes (contrary to the description of Hendel) slightly shorter than the 2nd.

Hind coxae and trochanters in female with extremely short and dense bristles covering their undersides, in male they are absent and only usual hairs are present (in female of *cribripennis* the brushes are also absent). Ovipositor distinctly longer than the remainder of body (in description of *punctulata* it is distinctly shorter). The different evidence concerning the length of ovipositor may be explained in terms of contraction of the body segments; it is improbable that there are two species distinguishable only on the length of the ovipositor.

Specimens examined.—WESTERN AUSTRALIA: Derby, 1 ♂ ("40–361"); Salmon Gums, 1 ♂ ("37–1514") (Perth Mus.).

Type, female, from Western Australia, in the British Museum.

E. punctulata is a typical representative of a group of species having more than 4 bristles on the scutellum; to this group also belong *E. inermis*, *E. norsemanica*, and *E. cribripennis*.

EPICERELLA CRIBRIPENNIS (Bezzi), ♂, ♀

Acropyrgota cribripennis Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 15.

Yellow legs, yellow sides of scutellum, brownish 3rd antennal joint, yellowish but not dark brown ground colour of wings, frons with 2 brown submedian spear-like longitudinal stripes. These characters easily separate the species from its congeners.

Specimens examined.—NEW SOUTH WALES: Young, 1.xii.1934, A. J. Nicholson, 1 ♂; Nyngan–Bourke, 22.x.1949, S. J. Paramonov, 2 ♂♂; Yass, 21, 27.xii.1929, K. English, 2 ♂♂; Wentworth Falls, Dec. 1928, H. C. Davis, 1 ♀; Uralla, 25.xi.1914, 1 ♀. SOUTH AUSTRALIA: White Well, *c.* 16 miles NE. of, 2.viii.1952, Calaby and McIntosh, 1 ♂. NORTHERN TERRITORY: Mountain Ck.–Dingo Ck., Wollogorang, 14.x.1930, T. G. Campbell, 1 ♂.

Type, male, from Bright, Vic., and allotype in the School of Public Health, and Tropical Medicine, University of Sydney.

EPICERELLA NORSEMANICA, sp. nov., ♀
(Plate 2, Fig. 9)

From *punctulata–cribripennis* group, nearer to *cribripennis*. Only the structure of the ovipositor is a solid character for identification. It is long and narrow, about 2·5 times longer than broad at base. In profile the underside is nearly straight, only the apex itself slightly curved downwards; in other species it is strongly curved downwards in its last third. It is narrowed twice, first at its mid point (but very slightly, hardly noticeable), again in its last third. Hairs on ovipositor very short, erect, not numerous.

Antennae brownish, palpi yellow. Legs brownish yellow. Yellow markings at sides of scutellum well developed. Wings with yellowish ground colour, lighter than in *cribripennis*. Whole surface of wing very uniformly spotted, with hyaline spots, but 3 black spots on stigma very well developed. Chaetotaxy as in other species. Hind coxae and trochanters without bristles.

Length of body 12·5 mm (with ovipositor), of wing 12·5 mm, of ovipositor 5 mm.

Specimen examined.—WESTERN AUSTRALIA: Norseman, 1 ♀ ("41–1089").

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA INERMIS, sp. nov., ♀

Belongs to the *punctulata* group, closely related to this species by dark colour of its wings, legs, and antennae. but distinctly smaller; the structure of ovipositor is quite different.

Frons with 2 nearly black submedian spear-like longitudinal stripes, not reaching the antennae; along the orbits there are 2 lateral stripes of same colour, extending below the base of antennae, occupying at apex the whole width of cheeks, but beginning before the orbital bristles. Postocellars comparatively weak. Chaetotaxy normal, scutellum with 6 bristles, sides of scutellum yellowish. Ground colour of wings dark brown, stigma black, with 1 hyaline spot near apex of subcostalis.

Ovipositor about as long as the remainder of abdomen, very broad at base, only slightly longer than broad; underside of ovipositor, in profile, nearly straight. Ovipositor densely haired above and below. Last third of its length nearly parallel-sided, about 4 times narrower than base of ovipositor.

Hind coxae and trochanters without distinct brushes of bristles, but haired and bristled.

Length of body 14·5 mm, of wing 12 mm, of ovipositor 4 mm.

Specimens examined.—SOUTH AUSTRALIA: Lowan Stn., 4 miles S. of Sherlock, 2.xii.1954, L. J. Chinnick, 1 ♀ (type); Ardrossan, 5.i.1951, H. M. Cane, 1 ♀ (not as dark as type).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA BELLA, sp. nov., ♂, ♀

Closely related to *E. miliacea* Hend., but readily distinguishable by reddish bristles on whole body, pattern of mesonotum, and transverse crest of vertex bearing 2 ocelli.

Ground colour of body reddish yellow; only head, mesonotum, and scutellum with some dark, nearly black, markings.

Head with a rather acute transverse crest in which are hidden 3 ocelli, arranged in 1 line; ocellar triangle quite absent. Vertex extremely broad, occupying at least half of head width. Frons velvety dark brown, the only yellow areas are very narrow stripes along the orbits, a spot on usual place of ocellar triangle, and 2 oblique narrow plates on which are placed 2 pairs of rather strong orbitals; there are also sparse short hairs on the front.

Cheeks and jowls brownish, nearly bare, with yellow spot on the level of base of antennae. Jowls as high as half diameter of eye. Facial carina very acute and protruding in profile. Peristomalia provided with short but noticeable hairs. Proboscis and palpi very short, the latter boomerang-like. Antennae rather long, 3rd joint distinctly longer than 2nd, acute at apex, its upperside excavated. Arista microscopically pubescent, 3-jointed, as long as antennae. Occiput becoming darker mesodorsally; 2 postocellar moderately strong decussate bristles; internal verticals very long, external about half as long. Occiput nearly bare, postorbital row of hairs weak.

Mesonotum with a very typical pattern, ground colour reddish, but with 2 sublateral parallel-sided and parallel velvety dark brown stripes extending from humeral calli to scutellum, but shortened before it. Discal part of mesonotum with 2 lighter longitudinal stripes of the same width, but shorter and regularly rounded at apices. All bristles reddish. A peculiarity of this spicies is the presence, on the level of last postalar bristle, of a pair of bristles on each side, i.e. behind the usual row of 4 bristles in front of scutellum.

Scutellum velvety dark brown, with reddish sides and narrow yellow mid line; 4 bristles. Postscutellum dark. Legs with 3 last joints of tarsi dilated. Hind coxae and trochanters, in both sexes, without brushes.

Wings with normal venation, colour paler than in *miliacea*. Stigma dark, with 4 yellow spots, apical part of wing darker, a distinct spot around crossvein *r-m*.

Abdomen narrower and shorter than thorax, with reddish hairs and bristles. Ovipositor solid, very broad at base, at apex about half as broad. Upperside humped, nearly bare.

Length of body 11 mm, of wings 14 mm, of ovipositor 4·5 mm.

Specimens examined.—WESTERN AUSTRALIA: Moingup, 6.vi.1953, G. Bornemissza, 1 ♂, 2 ♀♀.

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA GUTTIPENNIS Macquart

Epicerella guttipennis Macquart, 1850, Dipt. Exot. Suppl. 4. p. 294, tab. 27, figs. 9, 9*a*.

Since Macquart no author has given any additional description of this species; however, in Hendel's (1934, p. 143) key to identification of the species there are details which indicate that Hendel had seen the type of *E. guttipennis*: (1) scutellum hairless; (2) presutural bristles present; (3) r_{1+2} reaching costa before the *r-m*; (4) 2 dorsocentrals; (5) prosternum without bristles; (6) the 2nd antennal joint dorsally cleft; (7) m_{1+2}, before *r-m*, straight.

Hendel separated all other species and established for them a genus *Parepicerella* on account of the following differences: (1) 1 dorsocentral; (2) prosternum strongly bristled; (3) 2nd antennal joint dorsally without cleft; (4) vein m_{1+2}, before the vein *r-m*, involved in discal cell.

The author regards some of the abovementioned characters, e.g. the number of dorsocentrals, not sufficient to establish a new genus.

EPICERELLA PLAGIATA Bezzi

Epicerella plagiata Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 11.

Type, male, from Sydney, in the School of Public Health and Tropical Medicine, University of Sydney.

Another male specimen, from Mt. Lamington, Qld., collected on 5.xi.1943 by A. Blomberg, is preserved in the Australian Museum. It differs from the type only in that on one side of the mesonotum there are 3 dorsocentrals.

In this species the dark marking of the wing is distinctly more developed than in *E. setosa*; however, one cannot exclude the possibility that they are sexes of the same species.

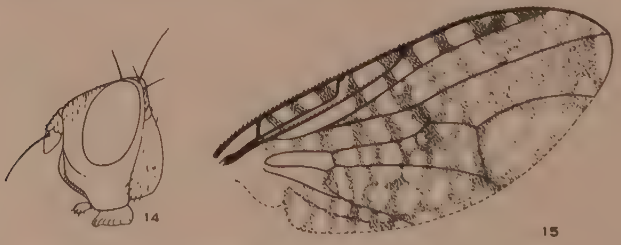
EPICERELLA SETOSA Bezzi

Epicerella setosa Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 12.

Type, female, from Milson I., N.S.W., in the School of Public Health and Tropical Medicine, University of Sydney.

EPICERELLA MULTIPUNCTATA Malloch
(Figs. 14, 15)

Epicerella multipunctata Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 27.



Figs. 14 and 15.— *Epicerella multipunctata* Mall.: 14, head; 15, wing.

Type and paratype, from Queensland, in the United States National Museum.

Enderlein (1942, p.100) erected for *E. multipunctata* a new genus, *Sestroptera*, and separated it from *Parepicerella* as follows:

"r_{4+5} nackt, wie bisher sonst immer. Ocellen fehlen ....*Sestroptera* n.g.
r_{4+5} basal behaart. Ocellen vorhanden ....*Parepicerella* Hend."

The author considers that these separational characters are insufficient to warrant the establishment of a new genus.

EPICERELLA MONTANA, sp. nov., ♂

Belongs to the group with spotted wings (dark spots on hyaline background, but not hyaline round spots on dark background).

Ground colour of body reddish yellow, only 3rd antennal joint and middle part of metanotum dark, nearly black.

Jowls extremely high, about as high as vertical diameter of eye. Cheeks in profile broad, about as broad as half horizontal diameter of eye. Facial carina not acute and well developed in profile on same level as cheeks. Face (clypeus) viewed from front, only slightly broader than cheeks. Antennae comparatively short. Third joint about as long as 2nd, ovoid, with quite rounded apex. Frons extremely broad, with short, erect, black hairs, covering also the upper part of cheeks. On each side only 1 black orbital bristle; the 2nd nearly absent. Ocelli present, ocellar spot dark. Two postocellars weak, directed forwards, slightly divergent.

Disc of mesonotum dark, but with a grey pollinosity causing it to seem to appear lighter. Four, poorly developed, longitudinal, brownish stripes can also be observed. Chaetotaxy normal, 4 scutellar bristles. Legs reddish yellow, last tarsal joints darker. Halteres yellow. Coxae and trochanters without brushes.

Wings hyaline with brown and yellow-brown spots. Stigma yellow, without "windows". Vein m_1 before *r-m* only slightly curved, apical section of m_1 also curved, but not so strongly as in other species. Pattern of wing without stripes or bands, wings irregularly spotted, but spots numerous, and well developed.

Abdomen short, slightly narrower than thorax, dull, with some black bristles at sides on tergites.

Length of body 10 mm, of wing 10 mm.

Specimen examined.—NEW SOUTH WALES: Mt. Kosciusko (summit), Feb. 1946, E. F. Riek, 1♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA MILIACEA Hendel, ♂, ♀
(Plate 1, Fig. 4; Plate 2, Fig. 10)

Epicerella miliacea Hendel, 1913, Arch. Naturgesch. A **11**: 112, fig. 12.

Third antennal joint short, rounded at apex; 2 pairs of orbitals; postocellars very weak, divergent; ocelli well developed; cheeks in profile narrow, occupying at most one-third of horizontal diameter of eye; mesonotum with 4 distinct brown longitudinal stripes, the middle pair shortened; scutellum dark brown, with yellowish, very contrasting sides; stigma normally with 3 hyaline "windows"; vein r_{2+3} in distal section usually with a short stump; coxae and trochanters with very short but extremely dense black brushes of spines; ovipositor distinctly shorter than the remainder of abdomen, curved downwards, densely haired only on underside; triangular and narrowed only in its apical fourth; postalar declivity with a black, round, very contrasting spot; postscutellum and metanotum brown, strongly contrasting with yellow surrounding areas (in many species this contrast is very weak); bristles on thorax comparatively long and robust.

This is the commonest species in Australia. The author has seen in the C.S.I.R.O. collection alone 70 ♂♂, and 37 ♀♀. The insects are active from November to the end of April, and are collected mainly in light traps.

Type, from Queensland, in the British Museum.

EPICERELLA UNIFORMA, sp. nov., ♀

Closely related to *E. nigrescens* and *E. miliacea* but smaller.

Ground colour of head brown or brown-red. Vertex occupying about one-third of head width. Ocelli reduced, nearly absent. One pair of strong orbitals. Postocellar very weak. Both pairs of verticals strong. Third antennal joint triangular, acute at apex, but without dorsal excavation. Cheeks narrow in profile, at most one-third of horizontal diameter of eye. Jowls less than half vertical diameter of eye.

Mesonotum with 4 distinct brown stripes similar to those of *E. miliacea*. No acrostichals, only 1 pair of dorsocentrals (prescutellar). Legs yellow, hind coxae without short brushes of bristles. Wings strongly variegated, with many round hyaline spots on brownish ground. Stigma in its basal half with 2 hyaline spots. Vein r_{1+2} with a short stump. Vein m_1 nearly straight at *r-m*, its distal portion slightly bowed. Scutellum yellow, with brown disc, 4 bristles. Halteres yellow.

Abdomen yellow, with long black bristles at sides of tergites and on hind margin of last. Ovipositor of type deformed, rather densely black-haired.

Length of body 7 mm, of wing 8 mm.

Specimen examined.—NEW SOUTH WALES: Braidwood, 10 miles SE. of, 18.xii.1951, T. G. Campbell, 1 ♀.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA CAMPBELLI, sp. nov., ♀

Belongs to the group with strongly but regularly variegated wings; closely related to *uniforma*.

It is sufficient to show only the main characters by which it differs from *uniforma*: (1) size is greater; (2) stigma has a hyaline spot in the apical half; (3) the vein m_1 in area of *r-m* is not straight; (4) apical portion of m_1 is more curved; (5) 1st ocellus developed (in *uniforma* reduced, nearly absent); (6) from a different locality.

It will be useful to add that in both species the frons is depressed in the middle, the 2nd antennal joint about as long as 3rd, and chaetotaxy is the same.

Length of body 10mm, of wing 11 mm.

Specimen examined.—TASMANIA: Corinna, Pieman R., 28.xii.1953, T. G. Campbell, 1 ♀.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA TRIANGULARIS Malloch
(Figs. 16, 17)

Epicerella triangularis Malloch, 1929, Proc. Linn. Soc. N.S.W. **54**: 26, text-figs. 4, 5.

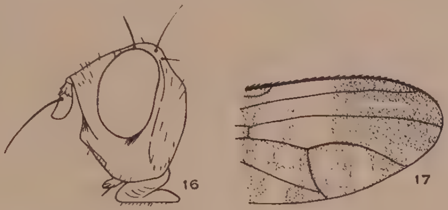
The author has not seen this species.

Type, male, from Cairns, N. Qld., in the United States National Museum.

EPICERELLA NIGRESCENS, sp. nov., ♂

Closely related to *miliacea*, but much smaller, darker, and with a different chaetotaxy.

Head dark brown; ocellar triangle yellow, with very small ocelli. One pair of strongly divergent orbitals. Postocellars weak. Vertex occupying slightly more than one-third of head width. Antennae short, 2 last joints subequal, the 3rd triangular, acute at apex. Jowls very high, about as high as two-thirds of vertical diameter of eye. Cheeks in profile occupying about one-third horizontal diameter of eye. Peristomalia with rather long hairs. Palpi dark, narrow.



Figs. 16 and 17.—*Epicerella triangularis* Mall.: 16, head; 17, apex of wing.

Mesonotum with 4 longtitudinal brown stripes, which are nearly confluent (broader than in *miliacea*). Two pairs of dorsocentrals. Scutellum, postscutellum, and metanotum uniformly dark, without yellowish contrasting spots at sides as in *miliacea*.

Wings strongly variegated, very dark, due to presence of many dark spots. Venation as in *miliacea*. Stigma with 2 hyaline spots in basal half. Halteres whitish. Legs brownish, with yellowish coxae and basal parts of femora.

Abdomen brownish, slightly narrower than thorax.

Length of body 7 mm, of wing 7 mm.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, Jan.–Mar. 1955, I. F. B. Common, 12 ♂♂ (all in light trap). NEW SOUTH WALES: Trangie, Mitchell Lab., 26.ii.1952, B. E. Cameron, 2 ♂♂. WESTERN AUSTRALIA: Fraser Range Gate, 57 miles E. of Norseman, 8.xii.1953, J. H. Calaby, 1 ♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA ACUTICORNIS, sp. nov., ♂, ♀

Closely related to *maculipennis–latifrons* group. A small, yellow species with spotted wings.

Form of head is very typical. Frons parallel-sided, very protruding, cheeks quite vertical, broad, occupying slightly less than a half horizontal diameter of eye. Three small, but well-developed ocelli present, situated on black ocellar tubercle. Vertex occupying slightly more than one-third of head width. No ocellar or postocellar bristles. Two pairs of rather strong orbitals. Inner verticals very long, strong, decussate; outer vertical about half as long. Occiput nearly bare. Jowls high, distinctly higher than half vertical diameter of eye, with vertical dark marking.

Peristomalia extremely narrow at end of facial foveae. Antennae comparatively long, especially the third joint; the latter triangular, elongate, very acute. Arista very long, microscopically pubescent. Palpi very narrow. Frons and cheeks (only above) with some short black hairs.

Chaetotaxy of mesonotum very unusual: presutural bristles absent; a pair of dorsocentrals situated far ahead of a pair of acrostichals; propleurae with only 3 small black bristles. Legs in both sexes (especially in female) with bristles on all femora above and below. Hind coxae of female with very strange quite flat but extremely dense brush of hairs, consisting of three parts; internal sides of hind trochanters in female with a tuft of scale-like hairs.

Wings variegated, with uniformly coloured stigma. Vein m_1 nearly straight in area of r-m as well as in its last section. Vein r-m situated quite perpendicularly to m_1. There are 4 spots of intensified colour: a crossband from costa to end of anal cell, a marking from costa to discal cell, at end of discal cell, and apex; the round hyaline spots are mostly in apical area.

Abdomen slightly darker than remainder of body, with black bristles at sides of tergites. Ovipositor about as long as rest of abdomen.

Length of body 5 mm, of wing 5 mm.

Specimens seen.—AUSTRALIAN CAPITAL TERRITORY: Canberra, 18.i.1951, S. J. Paramonov, 1 ♂ (type); Blundell's, 12.i.1931, A. L. Tonnoir, 1 ♀.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA STRUMOSA Bezzi

Epicerella strumosa Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 13.

The author can add some characters: at base of anterior femora on underside there is a long and strong bristle; on underside of sternopleurae only 1 bristle; 3 dorsocentral bristles, very closely to one another, the anterior only slightly ahead in comparison with acrostichals; ocellar triangle black, ocelli very small, but distinct; jowls very short, only about quarter of vertical diameter of eye; face very deeply sunken; 3rd antennal joint with an acute angle on upperside; no bristles on mid and hind femora, only hind femora have 1 on upperside in last third of their length.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Black Mountain, I. F. B. Common, 31.xii.1954, 1 ♂, Feb. 1955, 1 ♀, 21.iii.1955, 1 ♂, 1 ♀ (all in light trap). These four specimens are slightly different in size and wing pattern, but the author cannot find any substantial difference from *strumosa*.

Type, female, from Mosman, N.S.W., in the School of Public Health and Tropical Medicine, University of Sydney.

EPICERELLA MINOR Bezzi, ♂, ♀

Epicerella minor Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 15.

Female.—The author has examined a female which he regards as belonging to this species. Only difference from the type is: slightly more spotted wings (on stigma 3, but not 2, hyaline spots, under stigma 3 rounded hyaline spots, in type none). All other characters the same. Ovipostor very large, massive, twice as long as rest of abdomen, with sparse microscopic light hairs, but on underside near apex with 3 reddish bristles on each side; sternopleurae below with 2 bristles on each side.

Specimen examined.—NEW SOUTH WALES: Mt. Victoria, 28.ii.1936, D. F. Waterhouse, 1 ♀ (in Division of Entomology Museum, C.S.I.R.O., Canberra).

Type, male, from Mt. Kosciusko, N.S.W., in the School of Public Health and Tropical Medicine, University of Sydney.

EPICERELLA MACULIPENNIS Bezzi

Epicerella maculipennis Bezzi, 1929, Proc. Linn. Soc. N.S.W. **54**: 14.

Some characters can be added to the diagnosis of this species: (1) on the lowest point of occiput there is, in both sexes, on each side a rather strong bristle of the same size as those on propleurae, or stronger; (2) on underside of sternopleurae, in both sexes, on each side there are usually 3 bristles (rarely 2); (3) in male on upperside and on outerside of fore femora there are 9 distinct black bristles (in female they are absent); (4) jowls comparatively low, occupying distinctly less than half of vertical diameter of eye; (5) a distinct black marking always present from the costa to *r-m* (not interrupted).

Specimens examined.—NEW SOUTH WALES: Yass, 8.i.1930, Miss K. English, 2 ♂♂; Mt. Kosciusko, Digger's Creek, *c.* 5000 ft, 29.i.1933, Mackerras, 1 ♂. AUSTRALIAN CAPITAL TERRITORY: Lee's Springs, 29.iii.1951, S. J. Paramonov, 1 ♂; Black Mountain, 26.iii. 1930, L. F. Graham, 1 ♂. The author has also seen the male and female (in copula) determined by Bezzi.

Type, female, from Gisborne, Vic., in the School of Public Health and Tropical Medicine, University of Sydney.

EPICERELLA LATIFRONS, sp. nov., ♂

Closely related to *E. maculipennis*.

Head predominantly whitish. Antennae and middle of frons yellow; a strong brown marking under eye, clypeus and middle of face nearly black; no facial carina, only a single facial excavation. Upper half of occiput yellow, lower whitish. Palpi yellow, very narrow. Cheeks in profile narrow, narrower than 3rd antennal joint. Jowls as high as half vertical diameter of eye. Vertex very broad, occupying about half of head width. Ocellar tubercle and ocelli well developed, ocellar triangle black as also 2 spots with orbitals. There are 2 weak ocellars and 2 similar postocellars, 2 orbitals of same size (only slightly stronger). Third antennal joint nearly twice as long as 2nd, rounded at apex, but with very acute upper angle, as in *strumosa*.

Thorax yellow, brown on metanotum and postscutellum, whitish on metanotal lateral tubercles. Upper part of mesopleurae also whitish. Mesonotum with 4 not very distinct brownish longitudinal stripes. Presutural bristles in type broken. Two dorsocentral pairs. Acrostichals not in 1 row with dorsocentrals, nearer to scutellum. Sternopleurae below with 1 bristle on each side. Legs yellow, without peculiarities. Wings strongly variegated. Stigma with 2 hyaline spots. Vein m_1 at *r-m* nearly straight, its last portion distinctly cruved. A crossband from stigma to discal cell well developed.

Abdomen small, yellow, with some bristles at sides.

Length of body 6 mm, of wing 6 mm.

Specimens examined.—AUSTRALIAN CAPITAL TERRITORY: Blundell's, I. F. Graham, 15.iii.1950, 1 ♂, 26.iv.1930, 1 ♂; Black Mountain, 19.iv.1955, I. F. B. Common, 1 ♂ (in light trap). This specimen is slightly larger, with stronger wing markings and with only a basal hyaline spot on stigma, but probably belongs also to this species.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA ARMIPES, sp. nov., ♀

Very similar to *nigrescens*, the female of which is unknown, but cannot be accepted as it because of very strong armament of legs (the male of *nigrescens* has a usual leg structure).

Hind coxa and trochanter with a brush of very short, but extremely dense bristles, forming dark spots. All femora above and below (except upperside of mid femora) with rather numerous, strong, and long bristles. Only 1 pair of acrostichal and dorsocentral bristles, forming a row of 4 prescutellar bristles.

Ovipositor about as long as the remainder of abdomen, of usual triangular form, very broad at base, rather acute at apex, covered on both sides with black hairs, which are laterally longer. The basal half of discal cell is not so strongly narrowed as in *nigrescens*.

Length of body 6 mm, of wing 5·5 mm.

Specimen examined.—QUEENSLAND: Mt. Larcom, 18.iv.1955, Norris and Common, 1 ♀.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA IMITATRIX, sp. nov., ♂, ♀

Closely related to *minor* and *maculipennis*, but even larger than the latter. Its relationship with *minor* is not quite clear, as the female of the latter species is not known.

Head brownish yellow. Antennal foveae short, deeply sunken, the keel separating them nearly absent, the distance from their bases to edge of mouth cavity longer than distance to bases of antennae. Jowls very high, distinctly greater than half of vertical diameter of eye, with a dark elongated spot beneath the eye; the area at epistoma with short, dark hairs. Antennae very short, yellowish, upper corner of 3rd joint subacute. Palpi and proboscis yellow. Central stripe of frons brown. One pair of orbitals. Three ocelli, 2 very small ocellars, and 2 somewhat longer postocellars. Inner pair of verticals very long, convergent, nearly decussate.

Mesonotum brownish yellow, with 3 lighter, narrow, longitudinal stripes. Three pairs of dorsocentrals, 1 pair of acrostichals situated distinctly beyond the level of last pair of dorsocentrals. Pteropleurae and sternopleurae each with 1 strong bristle and 1 additional weak one.

Wings very spotted but without transversal fasciae or semi-fasciae. Vein m_1 under *r-m* not angulate, *r-m* situated beyond the middle of discal cell. Stigma in male with only 1 hyaline spot at base; in female there are 2. Vein r_{2+3} without additional veinlet.

Legs yellow; only hind femora and tibiae at apex dark, nearly black.

Abdomen brownish, with 1st segment longer than following 4 together, apex with some bristles on underside. Ovipositor in female longer than remainder of body, massive, broad at base, narrowing towards apex and curved downwards, with only microscopic sparse hairs covering it.

Length of body 10 mm, of wing 9 mm.

Specimens examined.—NEW SOUTH WALES: Braidwood, 13 miles SE. of, 14.x.1955, I. F. B. Common, 1 ♂, 1 ♀ (both in light trap).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA SIMULATRIX, sp. nov., ♂, ♀

Belongs to the group having quite hyaline wings. Very similar to *Osa commoni*, but apical part of 1st longitudinal vein comparatively longer and narrower. The 2nd antennal joint, as well as the obliquely situated cheeks, are very good characters for separation.

Head as in *commoni*, but cheeks narrow, having an oblique position, not parallel to each other. Frons distinctly broader. Three ocelli present. One pair of orbitals, 1 pair of weak postocellars, no ocellars; 2 pairs of verticals, the internal much stronger. Antennae deep black, 2nd joint about as long as the 3rd (in *commoni* longer), short, broad (in *commoni* with very narrow basal part); 2nd joint with very distinct lateral cleft (in *commoni* no cleft). Jowls very high, distinctly greater than half of vertical diameter of eye. Antennal foveae comparatively shorter, with a less pronounced keel. Proboscis and palpi similar.

Thorax yellow, without greyish dust, typical for *commoni*. Chaetotaxy similar. Wings as in *commoni*, but not quite hyaline, slightly yellowish. Apex of 1st longitudinal vein trypetid-like. Vein *r-m* noticeable beyond the middle of discal cell.

Legs similar to those of *commoni*, but without a greyish dust, nearly bristleless (in *commoni* bristle-like hairs are comparatively stronger and more numerous). Apices of femora and tibiae dark (in *commoni* the bases of tibiae are also dark). Characteristically with the dark markings on apices of femora especially well developed on underside.

Abdomen brownish, without noticeable difference from that of *commoni*. Ovipositor of female about as long as the other tergites together, typical for *Epicerella*, broad at base, narrowing towards apex, generally triangular, quite different from the ovipositor of *commoni*, which is extremely long, narrow, and spear-like.

Length of body 7·5 mm, of wing 7 mm.

Specimens examined.—NEW SOUTH WALES: Braidwood, 13 miles SE. of, 14.x.1955, I. F. B. Common, 2 ♂♂, 1 ♀ (all in light trap).

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA RAVA, sp. nov., ♀

A representative of a new group having quite hyaline wings, lacking both spots and fasciations.

Head brownish yellow, eyes black, with rather large facets. Proboscis fleshy, very short, yellow, with some long, yellow, bristle-like hairs. Palpi slightly longer than proboscis, broad, stripe-like, slightly clavate, with broad base, black, with short black hairs; base of palpi narrowly yellow. Antennal foveae deep, with strongly protruding middle keel, easily seen in profile. Antennae brown, 3rd joint slightly longer than the 2nd, subacute at apex; arista very long. Peristomalia parallel-sided at foveae, about as broad as antennae at widest point. Jowls high, at least half as long as largest diameter of eye. Face in profile very retreating. Cheeks broad, beneath foveae about as broad as half diameter of eye; with a rounded brown spot at level of base of 3rd antennal joint; cheeks and jowls nearly bare. Frons brown-yellow, with whitish sides. One pair of rather strong orbitals directed outwards.

Ocelli and ocellar tubercle quite absent, with a small ocellar triangle discernible only by its darker colour. Two postocellars directed forwards. A pair of strong internal and a pair of weaker external verticals. Cerebrale quite bare. Lowest point of occiput with some rather strong bristles. Frons with a very few short hairs.

Mesonotum brownish yellow, with 1 (very narrow) median and 2 sublateral greyish stripes. All bristles very strong. One very long humeral; 2 notopleurals; 1 presutural; 5 dorsocentrals, the anterior is presutural; 1 acrostichal (prescutellar); 2 postalars; 1 supra-alar. Scutellum bare, with 4 long bristles; 1 sternopleural (long), 1 pteropleural (long), about 3 bristles on mesopleurae.

Halteres whitish. Wings without pattern, but distinctly greyish on whole surface. Vein *r-m* slightly beyond the middle of discal cell, perpendicular to the vein m_1. Vein r_{2+3} without a stump. Legs reddish yellow, the apices of femora and tibiae darker. Hind trochanters and coxae with only some bristles. Claws and pulvilli comparatively short. Femora above and below with some strong bristles, excepting the upperside of the mid femora.

Abdomen, as whole body, reddish yellow, parallel-sided, all tergites laterally with some strong bristles. Ovipositor comparatively very short and solid, about as long as 3 last tergites together; it is broad, rounded at apex, and provided with a black appendix-like structure similar to a crossband. Ovipositor in its basal part quite glabrous, appearing polished, in apical part with some erect hairs; the black appendix with short, black hairs. The structure of ovipositor is unique amongst *Epicerella* species.

Length of body 9 mm, of wing 8 mm.

Specimen examined.—NEW SOUTH WALES: Braidwood, 18 miles SSE. of, 18.x.1955, I. F. B. Common, 1 ♀ (in light trap).

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA BARRINGTONI, sp. nov., ♂, ♀

Very similar to *miliacea*, but easily distinguishable by a number of morphological characters.

There is virtually only a single ocellus (the anterior); traces of the lateral ocelli are present, forming one straight line but not a triangle (in *miliacea* the triangle is small but fairly distinct). On cheeks below the base of antennae there is a rounded dark spot, present in both sexes (in *miliacea* it is absent). Only one pair of strong orbitals directed outwards (in *miliacea* the bristles are directed mostly backwards and another pair of smaller bristles are present as a rule). Median stripe on frons is lighter than the sides of it (in *miliacea* the median stripe is not developed).

Acrostichals on mesonotum quite absent, only a pair of dorsocentrals present, sometimes this pair is doubled, having another pair nearby on very short distance. Sides of scutellum as in *miliacea*, yellow, contrasting with a dark brown middle part. No essential difference in colour and venation from *miliacea*.

Legs similar to those of *miliacea*, but the hind femora in both sexes on underside without bristles (which are numerous in *miliacea*). The short but extremely dense brushes on hind coxae in the female of *miliacea* are quite absent in this species.

Ovipositor in this species is not so densely covered with hairs as in *miliacea*.

Length of body 12 mm, of wing 13 mm.

Specimens examined.—NEW SOUTH WALES: Tubrabucca Ck., Barrington Tops, I. F. B. Common, 8.i.1956, 3 ♀♀, 10.i.1956, 1 ♂ (all in light trap).

Type, male, in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA NOCTUA, sp. nov., ♂

Closely related to *setosa* and *plagiata*, belonging to the group with more banded than spotted wing. Among the 27 species of *Epicerella*, this species has the most extensively darkened wings.

Head yellowish, only epistomal area and facial keel and the upper third of occiput brownish; the median stripe on frons is yellowish brown.

Vertex distinctly broader than one-third of head width. Ocelli and ocellar tubercle absent, this place is darkened; ocellar bristles (2) although very weak, are present; 2 pairs of orbitals, the anterior much stronger. Postocellars small, divergent. Both pairs of verticals are about equally strong.

Jowls high, occupying slightly less than half of vertical diameter of the eye. Antennae brownish, 3rd joint at apex rounded.

Mesonotum with 4 distinct brownish stripes. Two pairs of dorsocentrals, the last one on the same level with acrostichals. Sides of thorax with 2 very contrasting colours: upper part yellowish, most parts of mesopleurae, pteropleurae, and sternopleurae shiny brown. Pteropleurae with 3 bristles, 1 very strong. Legs brownish with lighter tibiae and tarsi. Halteres yellow.

Crossvein *r-m* exactly in the middle of discal cell, the vein m_1 under crossvein *r-m* quite straight, not angulate. Vein r_{2+3} without a stump and without a distinct curve, nearly straight. Stigma brown, with a small yellow spot at base.

Wing pattern represented mostly by 2 broad fasciae: one apical outside of the level of the crossvein *t-p*, and another crossing the basal half of discal cell. Crossvein *t-p* is straight and broadly bordered by brown colour on both sides; vein m_2 also broadly bordered by brown, in the middle of discal cell a large brown spot.

Disc of scutellum brown, only margins yellowish. Postscutellum and metanotum brown.

Abdomen yellowish brown, last tergite laterally darker. At sides of tergites some very long bristles along the whole lateral margin.

Length of body 8 mm, of wing 7 mm.

Specimen examined.—VICTORIA: Gellibrand, 6 miles S. of, 750 ft, 15.ii.1956, I. F. B. Common, 1 ♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

EPICERELLA PILOSOCULA, sp. nov., ♂

Belongs to the group with spotted but not fasciated wings, differing from all species of *Epicerella* by its distinctly haired eyes.

Face and frons brownish, rest of head yellow.

Vertex occupying only about one-third of head width. Three small but distinct ocelli and ocellar tubercle present, but ocellar bristles quite absent. Two pairs of orbitals, but the 2nd one very weak. Postocellars strongly divergent. The hairs on frons in antennal area bristle-like. Third antennal joint at apex subacute. Jowls as high as a half of vertical diameter of eye. Eyes haired.

Mesonotum with 4 distinct brown longitudinal stripes. One pair of dorsocentrals, distinctly not in 1 row with the acrostichals. Scutellum brown, but sides yellow. Legs yellowish.

Pattern of wings not very well developed and pale. Stigma with yellowish spot at base and in the middle. Vein r_{2+3} not quite straight, but with a curve on the level of crossvein *t-p*. Crossvein *r-m* distinctly beyond the middle of discal cell, vein m_1 under crossvein *r-m* slightly angulate. Crossvein *t-p* is not quite straight. Only apical part of wing is more darkened. Wings extremely long and broad.

Abdomen brownish.

Length of body 7 mm, of wing 8 mm.

Specimen examined.—VICTORIA: Wannon Divide, Grampians, 1400 ft, 8.ii.1956, I. F. B. Common, 1 ♂.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

Genus COMMONIELLA, gen. nov.

Generotype *Commoniella noctua*, sp. nov.

Closely related to *Epicerella*, but distinguishable by: (1) large, broadened palpi which are longer than proboscis; (2) lack of ocelli, ocellar tubercle, and even traces of them; (3) presence of only a pair of orbitals on the head, directed forwards, and a pair of long, decussate internal verticals; (4) presence of elongated bristles on front at base of antennae; (5) presence, on mesonotum, of only 1 bristle on humeral calli, 2 on postalar calli, 2 notopleurals, 1 supra-alar bristle (acrostichal and dorsocentral bristles absent); (6) only 2 apical, very closely situated bristles on scutellum; (7) shape of vein r_{2+3}—before the stump of the vein it makes a distinct bow towards the costa; (8) crossvein *r-m* a little before the middle of discal cell; (9) the outer crossvein *t-p* strongly excavated, forming a very long and acute angle at lower corner of discal cell; (10) extremely unusual shape of ovipositor; it is strongly inflated, balloon-like, about as long as the remainder of abdomen, apical part rounded.

The author has named this genus in honour of Mr. I. F. B. Common, to whom he is indebted for many interesting flies, especially pyrgotids.

COMMONIELLA NOCTUA, sp. nov., ♀

Ground colour of body yellow, only eyes with very large facets, dark. From lower point of eye a dark marking towards the mouth-edge. Antennal foveae extremely long, much longer than the remainder of the facial part of head, keel well developed. Cheeks in profile very narrow; very narrow jowls are twice broader than cheeks, being at most as long as one-third of vertical diameter of eye. Third antennal joint conical, at apex rounded, subacute, about as long as both basal joints combined.

Mesonotum slightly darker than the sides of thorax. One strong pteropleural and 1 strong sternopleural bristle. Wings spotted similarly to *E. miliacea*, but not so intensive. Pterostigma brownish, with 2 lighter yellowish spots, but they are not so hyaline as usual "windows". Legs practically bristleless, rather long and slender, only coxae with some not very strong bristles; some strong bristles on lower part of sternopleurae.

Abdomen short, with some long bristles laterally, but ovipositor nearly as long as the rest of abdomen, nearly bare, only at base laterally haired. Ovipositor is very inflated, balloon-like, apical part with a brush of short hairs.

Length of body 8·5 mm, of wing 8 mm.

Specimens examined.—QUEENSLAND: Mt. Spec, 2900 ft, 22.iv.1955, Norris and Common, 1 ♀; Bunya Mts., 26.iii.1957, E. F. Riek, 1 ♀.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

COMMONIELLA FREDERICKI, sp. nov., ♀

Closely related to *noctua*, but distinguishable at once by the presence of 4 dark spots on mesonotum, and behind the anterior spiracle on each side.

Whole body reddish yellow. Eyes black, with large facets. Cheeks in profile rather broad, about equal to one-third the horizontal diameter of eye. Jowls not high, smaller than one-half the vertical diameter of eye. Vertex narrower than one-third of head width. Frons very protruding. One pair of medium-sized orbitals. One pair of inner verticals, situated parallel. Some hairs at base of antennae. On occiput only 1 pair of small bristles at upper corner of "collare". Antennae long, 3rd joint elongated, at apex attenuated. Palpi flat, but not as broad as in *noctua*, slightly longer than proboscis.

Mesonotum with 4 sublateral dark spots, 1 pair before the sutura laterally, a 2nd pair just behind the sutura. One humeral bristle, 2 notopleural, 1 dorsocentral (prescutellar), 1 intra-alar, 2 postalar; only 2 bristles on scutellum; 1 strong bristle on mesopleurae, 1 on pteropleurae.

Legs quite yellow, long, claws long. Two strong bristles at apex of the flattened anterior coxae, on anterior side. On underside of anterior femora at base 1 bristle, but not strong. On sternopleurae, quite below, 2 bristles on each side. On mid coxae 2 bristles above and below, 1 bristle at base of mid femora; 1 bristle on posterior coxa and 1 not strong bristle at base of posterior femora. Venation of wing similar to that of *noctua*, but the crossvein *r-m* is situated at the middle of the discal cell, and not before it, and the vein m_1, at crossvein *r-m*, is distinctly angulated (in *noctua* it is here straight). The lower corner of 2nd posterior cell is very long and acute, as in *noctua*. Wing pattern as in *noctua*, but more reduced, pale.

Abdomen yellow, with large, bulbous ovipositor which occupies distinctly less than one-half of abdomen length. At sides of tergites 1 strong black bristle. Structure of the underside of ovipositor complicated.

Length of body 9 mm, of wing 9 mm.

Specimen examined.—QUEENSLAND: Carnarvon Gorge, 1.iv.1957, E. F. Riek, 1 ♀.

Named after Mr. E. F. Riek, to whom the author is indebted for many interesting specimens.

Type in the Division of Entomology Museum, C.S.I.R.O., Canberra.

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Explanation of Plates 1 and 2

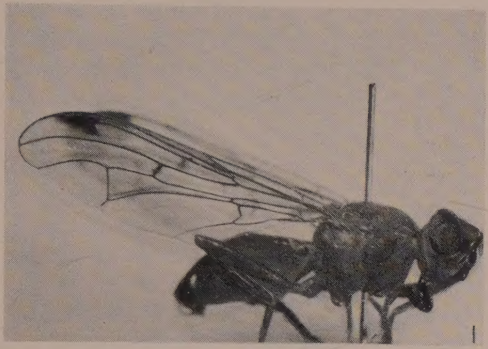
Plate 1

Fig. 1.—*Adapsilia gratiosa*, sp. nov., ♂.
Fig. 2.—*Paratoxura norrisi*, sp. nov.
Fig. 3.—*Pyrgella carnei*, sp. nov.
Fig. 4.—Wing of *Epicerella miliacea* Hend.
Fig. 5.—*Frontalia genalis* Mall., ♀.
Fig. 6.—*Musgravena anthonyi*, sp. nov.
Fig. 7.—*Facilina commoni*, sp. nov., ♀.
Fig. 8.—Wing of *Epicerella punctulata* Hend.

Plate 2

Fig. 9.—*Epicerella norsemanica*, sp. nov.
Fig. 10.—*Epicerella miliacea* Hend.
Fig. 11.—*Frontalia bredboana*, sp. nov., ♂.
Fig. 12.—*Nicholsonia curvinervis* (Bezzi), ♀.
Fig. 13.—*Osa sinclairae*, sp. nov., ♀.
Fig. 14.—*Adapsona fulva*, sp. nov., ♀.
Fig. 15.—*Osa commoni*, sp. nov., ♀.
Fig. 16.—*Osa bornemisszai*, sp. nov., ♀.

REVIEW OF AUSTRALIAN PYRGOTIDAE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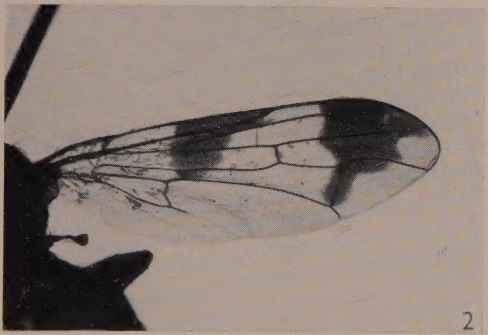
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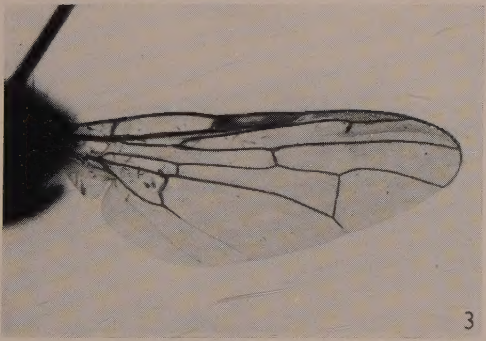
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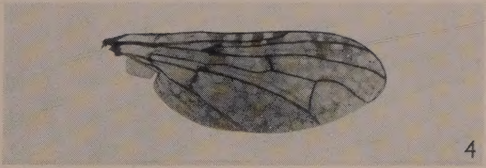
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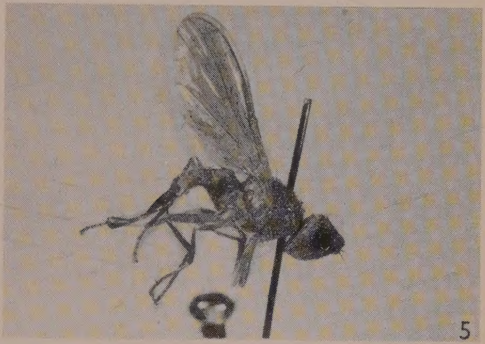
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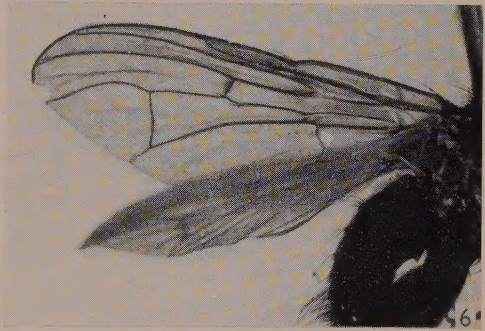
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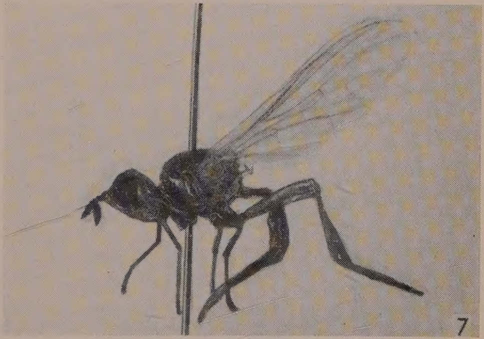
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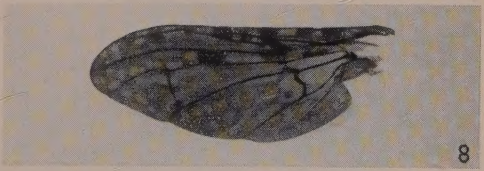
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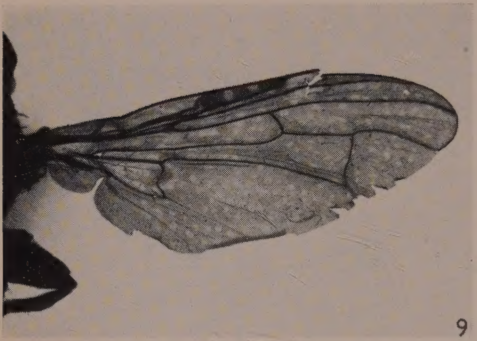
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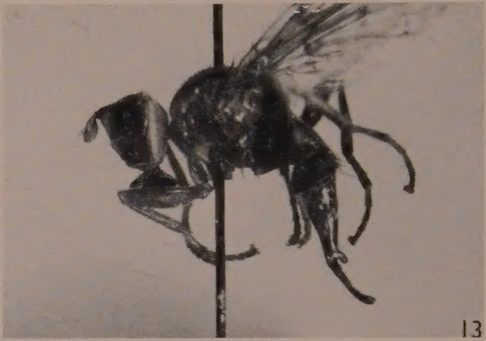
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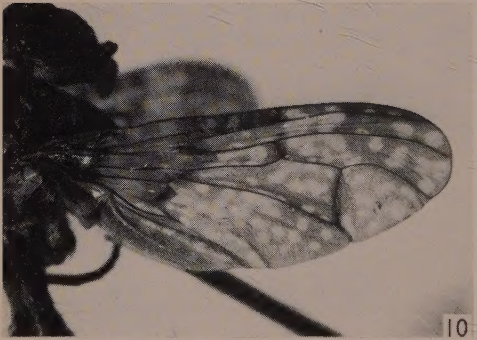
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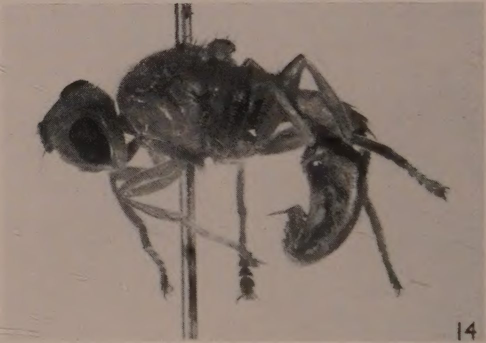
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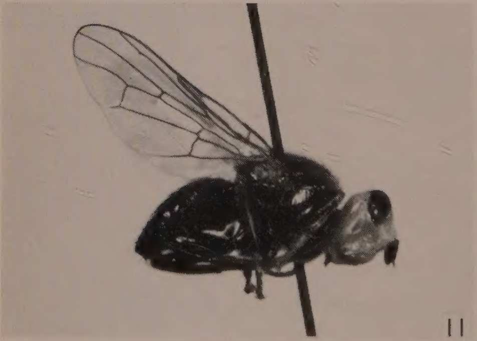
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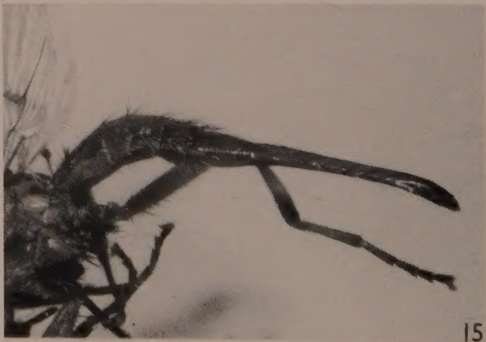
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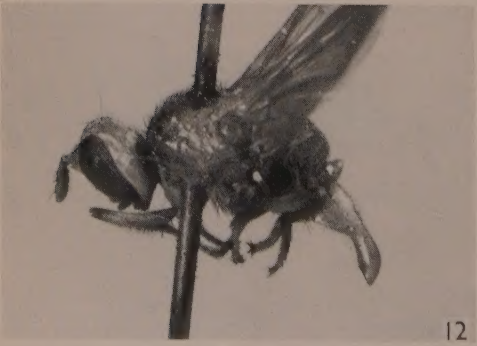
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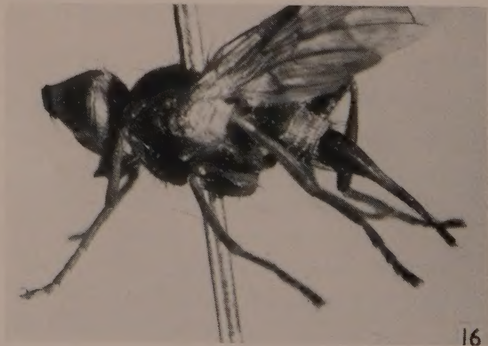
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